CLUB BUILDING FOR THE PEORIA COUNTRY CLUB, PEORIA, ILL.
Herbert Edmund Hewitt, Architect, Peoria, Ill. For plan, see next succeeding plate.

Cyclopedia
of
Architecture, Carpentry and Building

ON ARCHITECTURE, CARPENTRY, BUILDING, SUPERINTENDENCE, CONTRACTS, SPECIFICATIONS, BUILDING LAW, STAIR-BUILDING, ESTIMATING, MASONRY, REINFORCED CONCRETE, STEEL CONSTRUCTION, ARCHITECTURAL DRAWING, SHEET METAL WORK, HEATING, VENTILATING, ETC.

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Grateful acknowledgment is here made also for the invaluable co-operation of the foremost architects, engineers, and builders in making these volumes thoroughly representative of the very best and latest practice in the design and construction of buildings; also for the valuable drawings and data, suggestions, criticisms, and other courtesies.

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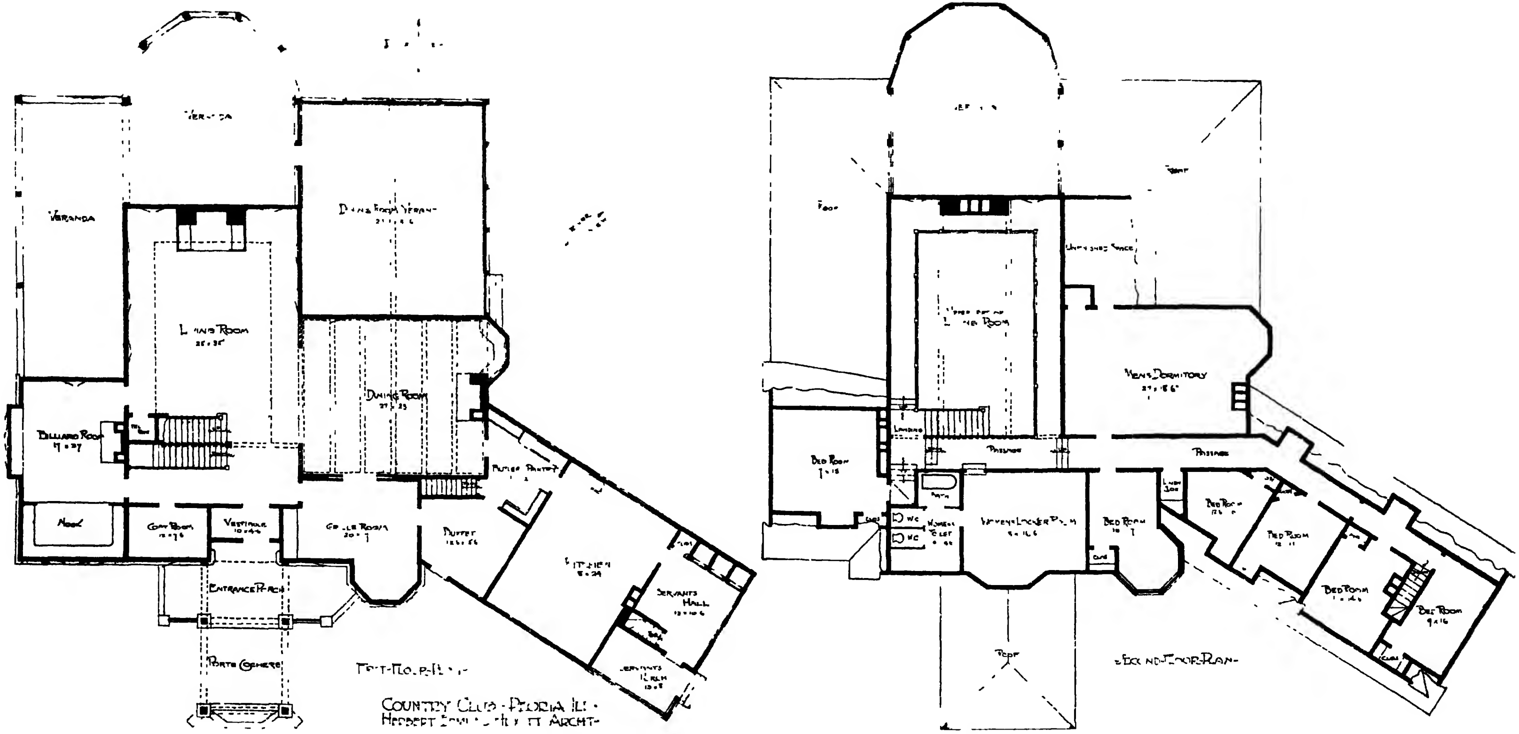
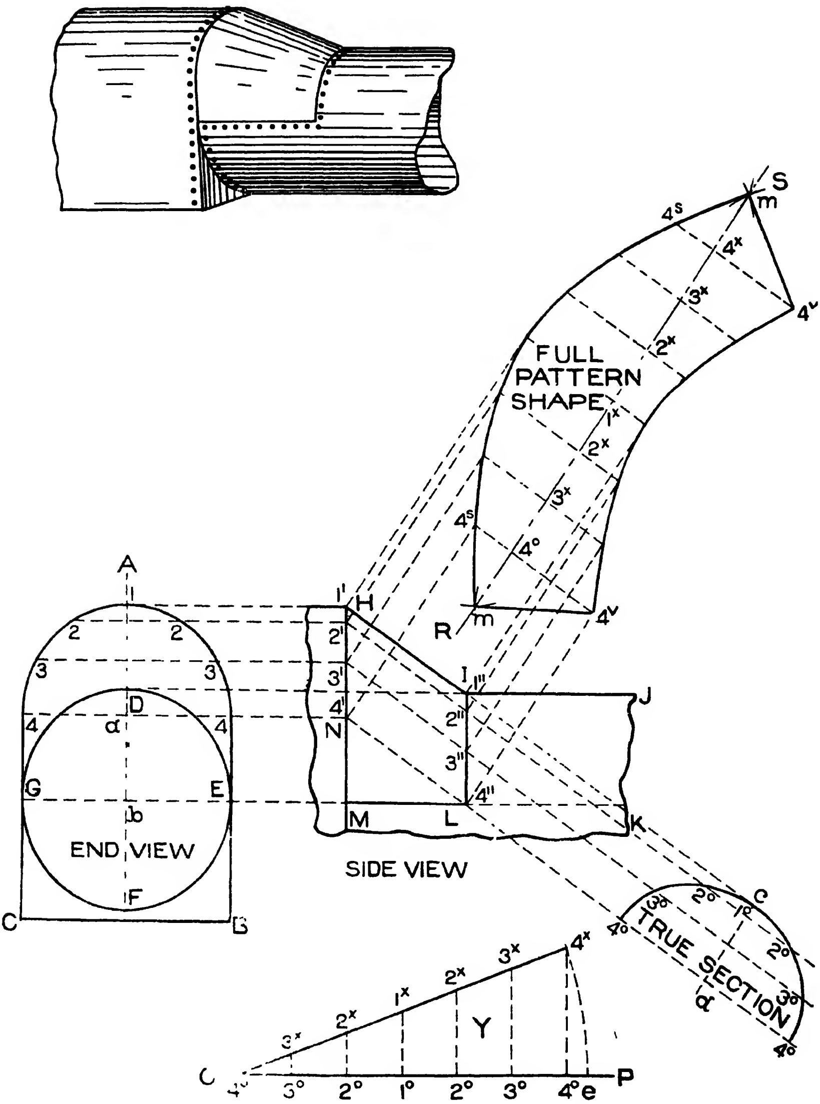


PLANS OF THE PEORIA COUNTRY CLUB, PEORIA, ILL

Herbert Edmund Hewitt, Architect, Peoria, Ill.

For Exterior View, Reproduced in Color, See Frontispiece in this Volume.



PATTERN FOR GUSSET SHEET OF BOILER, SHOWING DEVELOPMENT.

Foreword

THE rapid evolution of constructive methods in recent years, as illustrated in the use of steel and concrete, and the increased size and complexity of buildings, has created the necessity for an authority which shall embody accumulated experience and approved practice along a variety of correlated lines. The Cyclopedia of Architecture, Carpentry, and Building is designed to fill this acknowledged need.

There is no industry that compares with Building in the close interdependence of its subsidiary trades. The Architect, for example, who knows nothing of Steel or Concrete construction is to-day as much out of place on important work as the Contractor who cannot make intelligent estimates, or who understands nothing of his legal rights and responsibilities. A carpenter must now know something of Masonry, Electric Wiring, and, in fact, all other trades employed in the erection of a building; and the same is true of all the craftsmen whose handiwork will enter into the completed structure.

Neither pains nor expense have been spared to make the present work the most comprehensive and authoritative on the subject of Building and its allied industries. The aim has been, not merely to create a work which will appeal to the trained

expert, but one that will commend itself also to the beginner and the self-taught, practical man by giving him a working knowledge of the principles and methods, not only of his own particular trade, but of all other branches of the Building Industry as well. The various sections have been prepared especially for home study, each written by an acknowledged authority on the subject. The arrangement of matter is such as to carry the student forward by easy stages. Series of review questions are inserted in each volume, enabling the reader to test his knowledge and make it a permanent possession. The illustrations have been selected with unusual care to elucidate the text.

¶ The work will be found to cover many important topics on which little information has heretofore been available. This is especially apparent in such sections as those on Steel, Concrete, and Reinforced Concrete Construction; Building Superintendence; Estimating; Contracts and Specifications, including the principles and methods of awarding and executing Government contracts; and Building Law.

¶ The Cyclopedia is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence, and the method adopted in its preparation is that which this School has developed and employed so successfully for many years. This method is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best yet devised for the education of the busy working man.

¶ In conclusion, grateful acknowledgment is due the staff of authors and collaborators, without whose hearty co-operation this work would have been impossible.

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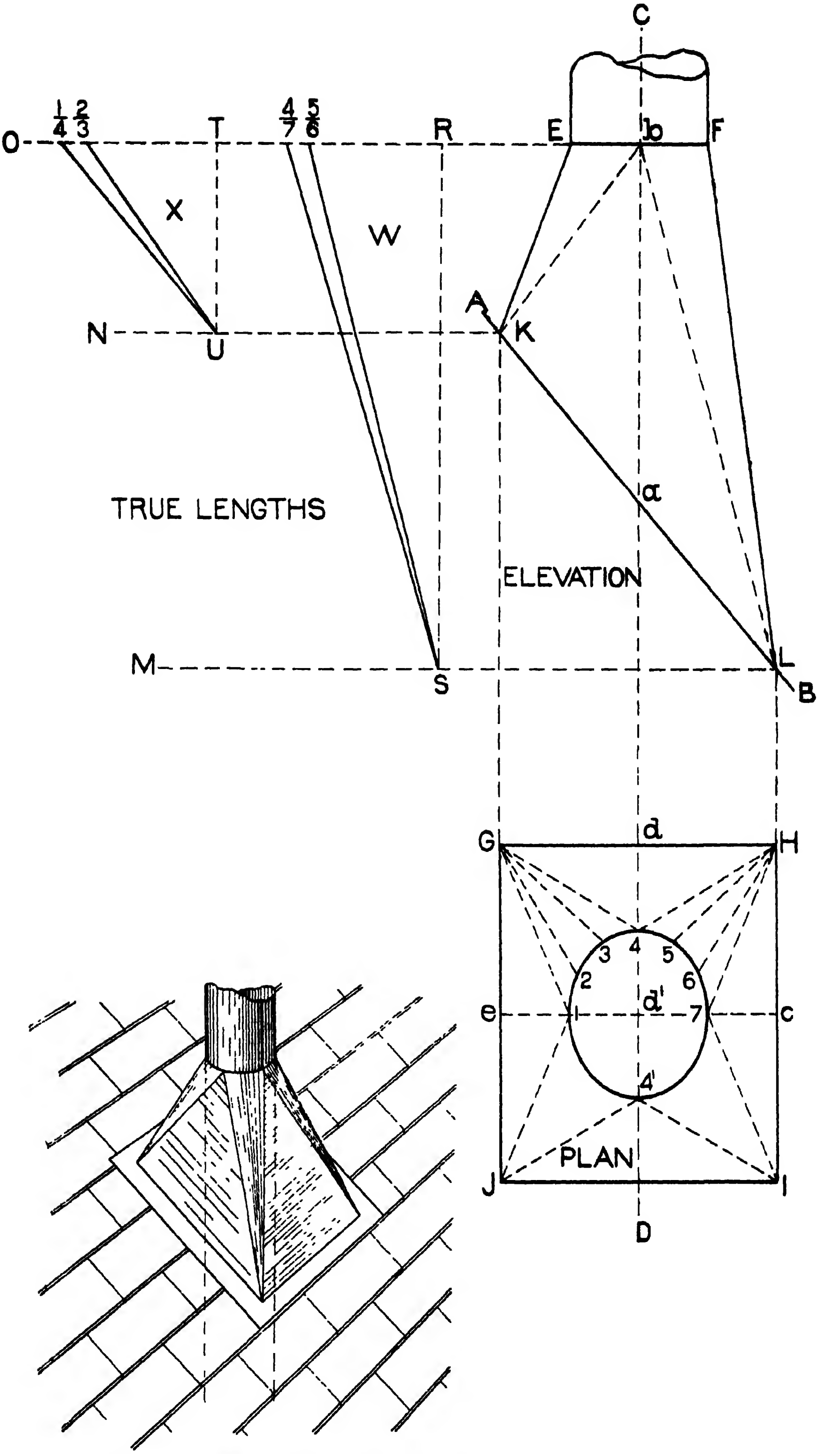


PATTERN OF TAPERING FLANGE FOR CYLINDER, DEVELOPED BY TRIANGULATION.

TINSMITHING.

An important part of the technical education of those connected with tinsmiths' work is a knowledge of laying out patterns. When making the various forms of tinware, or, as they are commonly called, housefurnishing goods, the greatest care must be taken in developing the patterns, for if a mistake of but one point is made, the pattern will be useless. There are general geometrical principles which are applied to this work which, when thoroughly understood, make that part plain and simple, which would otherwise appear intricate. These principles enable the student to lay out different patterns for various pieces of tinware where the methods of construction are similar.

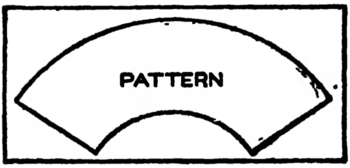


Fig. 1.

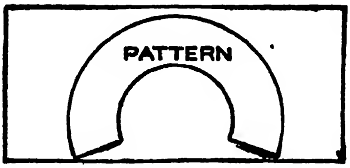


Fig. 2.

Construction. Before laying out the pattern for any piece of tinware, the method of construction should be known. Knowing this, the first thought should be: Can the pattern be developed and cut from one piece of metal to advantage, as shown in Fig. 1, or will it cut to waste, as shown in Fig. 2? Will the articles have soldered, grooved or riveted seams, as shown respectively by A, B and C, in Fig. 3? Also, will the edges be wired or have hem edges at the top, as shown respectively by A and B, in Fig. 4? Sometimes the pattern can be laid out in such a way that the article may be made up of two or more pieces, so that the patterns may be laid in one another, as shown in Fig. 5, thereby saving material. This is a plan that should always be followed if possible.

When the patterns are developed, tin plate should be obtained of such size as to have as little waste as possible.

By means of the table on pages 45–47 tin plate may be ordered

which will cut to advantage, for there is nothing worse in a tin-shop than to see a lot of waste plate under the benches, whereas a little foresight in ordering stock would have saved material.

Capacity of Vessels. Sometimes the tinsmith is required to make a piece of tinware which will hold a given quantity of liquid. The methods of finding the dimensions are given in Arithmetic and Mensuration, which subjects should be reviewed before beginning this work.

Shop Tools. The most important hand tools required by the tinsmith are: hammer, shears, mallet, scratch awl, dividers and soldering coppers. The other tinsmith tools and machines will be explained as we proceed.

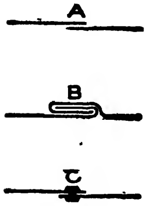


Fig. 3.

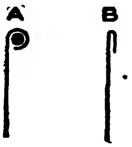


Fig. 4.

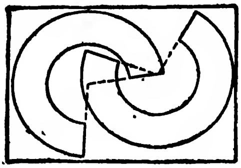


Fig. 5.

Various Methods of Obtaining Patterns. The pattern drafting for this course is divided into two classes:

1. Patterns which are developed by means of parallel lines.
2. Patterns which are developed by means of radial lines.

The principles which follow are fundamental in the art of pattern cutting, and their application is universal in tinsmiths' work.

INTERSECTIONS AND DEVELOPMENTS.

The laying out of patterns in tinsmiths' work belongs to that department of descriptive geometry, known as development of surfaces, which means the laying out flat of the surfaces of the solids, the flat surfaces in this case being the tinplate. In Fig. 6 is shown one of the most simple forms to be developed by parallel lines, that of an octagonal prism. This problem explains certain fixed rules to be observed in the development of all parallel forms, which are as follows:

1. There must be a *plan*, *elevation* or other view of the article to be made, showing the line of joint or intersection, and

in line with which must be drawn a section or profile of the article. Thus, ABCD shows the view of the article, AL the line of joint or intersection, and E the profile or section of the article.

2. The *Profile* or section (if curved) must be divided into equal spaces (the more spaces employed the more accurate will be the pattern), from which lines are drawn parallel to the lines of the article intersecting the line of joint or intersection. Thus from the corners numbered 1 to 8 in the profile E, lines are drawn

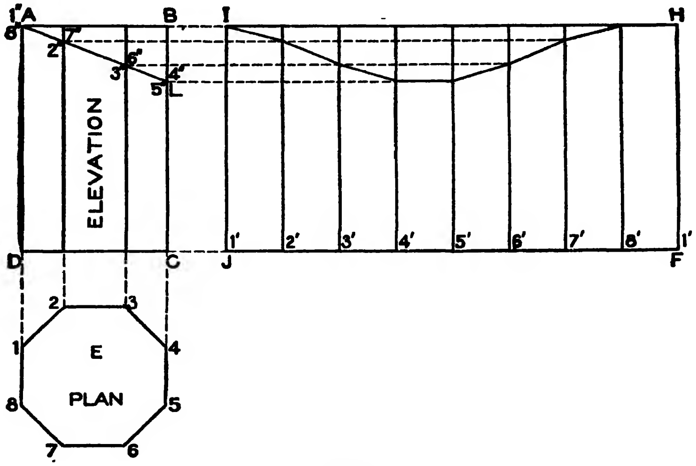


Fig. 6.

parallel to the line of the article, intersecting the line of joint AL from 1″ to 8″. In Fig. 7, where the section A is curved, this is divided into equal spaces.

3. A *stretchout* line (showing the amount of material the article will require) is next drawn at right angles to the line of the article, upon which is placed each space contained in the section or profile. Thus JF, in Fig. 6, is the stretchout line, which contains the true amount required to enclose the profile E.

4. At right angles to the stretchout line, and from the intersections thereon, draw lines called the *measuring lines*. Thus, from the intersections 1′ to 8′ on JF lines are drawn at right angles to the stretchout line JF, which are called measuring lines.

5. From the intersections on the line of joint draw lines intersecting similarly numbered measuring lines, which will result in the pattern shape. Thus lines drawn from the intersections on

the line AL at right angles to BC intersect similarly numbered measuring lines as shown. Then JIHF will be the development for an octagonal prism intersected by the line AL in elevation.

This simple problem shows the fundamental principles in all parallel-line developments. What we have just done is similar to taking the prism and rolling it out on a flat surface. Let the student imagine the prism before him with the corners blackened

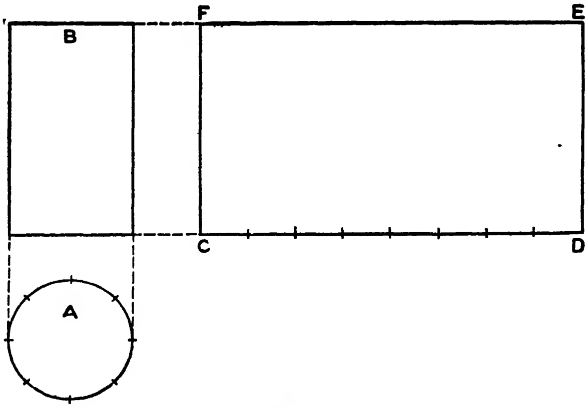


Fig. 7.

and starting with corner 1 turn the prism on a sheet of white paper until the point 1 is again reached, when the result will correspond to the development shown. Bearing these simple rules in mind, the student should have no difficulty in laying out or developing the forms which will follow.

Fig. 7 shows the development of a cylinder, and also shows the principles which are applied in spacing circular sections or profiles, as explained for parallel developments. A shows the profile or section, B the elevation; and CD the stretchout line or the amount of material required to go around the circle. By drawing the measuring lines CF and DE and connecting them by the line FE, we obtain CDEF, which is the development of the cylinder.

Fig. 8 shows how to obtain the development of the surfaces of an intersected hexagonal prism, the angle of intersection being 45°. First draw the elevation ABCD and the section E in its proper position below. Number the corners in the section 1, 2 and 3, as shown, from which erect perpendicular lines intersecting the

plane AB, as shown by 1°, 2° and 3°. Bisect the lines 1—1 and 3—3 in plan obtaining the points F and H respectively, and draw the line FH. This line will be used to obtain dimensions with which to construct the developed surface on the plane AB. At right angles to AB and from the intersections 1°, 2° and 3° draw lines as shown. Parallel to AB draw the line F^v H^v. Now, measuring in each instance from the line FH in E, take the distances to 1, 2 and 3, and place them on similarly numbered lines drawn from the plane AB, measuring in each instance from the

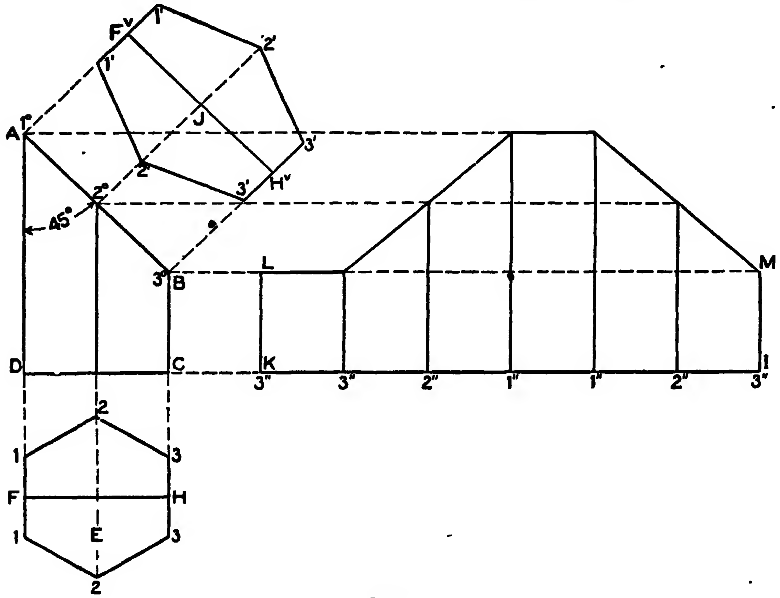


Fig. 8.

line $F^v H^v$ on either side, thus obtaining the points 1′, 2′ and 3′. Connect these points by lines as shown; then J will be the true development or section on AB.

For the development of the prism, draw the stretchout line KI at right angles to AD, upon which place the stretchout of the section E, as shown by similar numbered intersections on KI. From these intersections, at right angles to KI, draw the measuring lines shown, which intersect with lines drawn from similar numbered intersections on the plane AB, at right angles to BC. Through the intersections thus obtained, draw the lines from L to

M. Then KLMI will be the pattern or development of the intersected prism.

Fig. 9 shows the development of an intersected cylinder. A is the elevation and B the profile or plan. As each half of the development will be symmetrical, divide the profile B into a number of equal parts, numbering each half from 1 to 5, as shown. From these points perpendicular lines are erected, intersecting the plane 1^v — 5^v at 1^v, 2^v, 3^v, 4^v and 5^v. A stretchout is now made of the profile B and placed on the horizontal stretchout line CD, the points being shown by 5′, 4′, 3′, 2′, 1′, 2″, 3″, 4″ and 5″. From

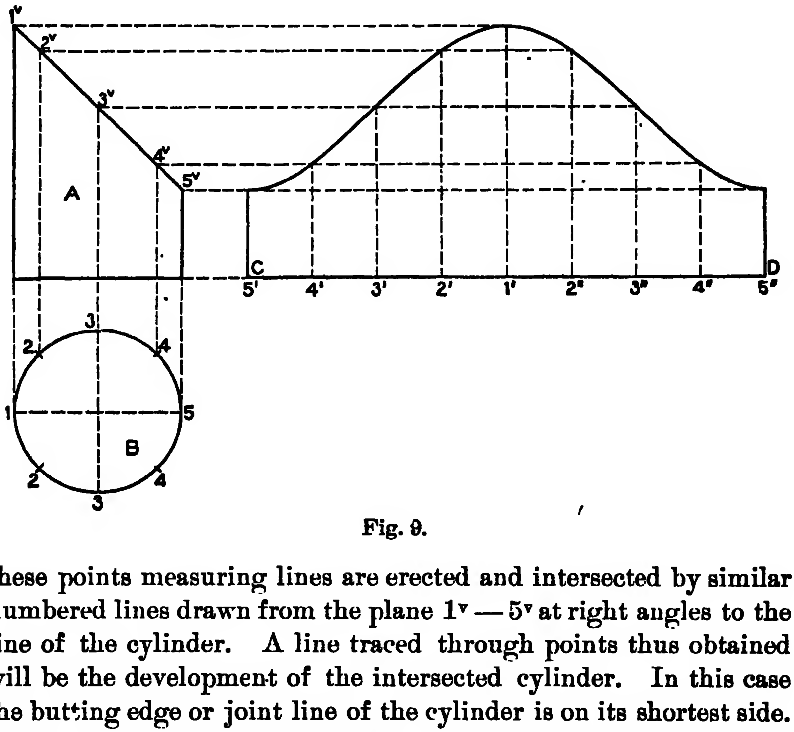


Fig. 9.

these points measuring lines are erected and intersected by similar numbered lines drawn from the plane 1^v — 5^v at right angles to the line of the cylinder. A line traced through points thus obtained will be the development of the intersected cylinder. In this case the butting edge or joint line of the cylinder is on its shortest side. If the butting edge were desired on its longest side, it would be necessary to change only the figures on the stretchout line CD, making 1′ start at 5′ and end at 5″.

Where two prisms intersect each other, as shown in Fig. 10, it is necessary to find the points of intersection before the surfaces can be developed. Thus we have two unequal quadrangular

prisms intersecting diagonally at right angles to each other. We first draw the section of the horizontal prisms as shown by B in the end view, from which the side view A is projected as shown. From the corner T in the section B erect the perpendicular line TC, and above in its proper position draw the section D of the vertical prism, and number the corners 1, 2, 3 and 4. From the corners 1 and 3 drop vertical lines intersecting the profile B at 1′ and 3′, T representing the points 2′ and 4′ obtained from 2 and 4 in D. From the points 1′ and 3′ in B, draw a horizontal line through the side view, and locate the center of the vertical prism as 3″, from which erect the perpendicular line 3″ — 1. Now take a duplicate of the section D and place it as shown by F, allowing it to make a quarter turn (90°); in other words, if we view the vertical prism from the end view, the point 1 in section D faces the left, while if we stood on the right side of the end view the point 1 would point ahead in the direction of the arrow. The side view therefore represents a view standing to the right of the end view, and therefore the section F makes a quarter turn, bringing the corner 1 toward the top. From points 2 and 4 in section F drop vertical lines intersecting the line drawn from the corner 2′ — 4′ in B, thus obtaining the intersections 2″ — 4″ in the side view. Draw a line from 4″ to 3″ to 2″, which represents the intersection between the two prisms.

To develop the vertical prism, draw the horizontal stretchout line HI, and upon it place the stretchout of the profile D as shown by similar figures on HI. Draw the measuring lines from the points 1, 2, 3, 4, 1, at right angles to HI, which intersects with lines drawn at right angles to the line of the vertical prism from intersections having similar numbers on B. A line traced through the points thus obtained, as shown by HILJ will be the development of the vertical prism. The development of the horizontal prism with the opening cut into it to admit the joining of the vertical prism is shown in Fig. 11, and is drawn as follows: Draw any vertical line O^v P^v, and on this line place the stretchout of the upper half of section B in Fig. 10, as shown by similar letters and figures in Fig. 11. From these points at right angles to O^v P^v draw lines equal in length to the side view in Fig. 10. Draw a line from U to T in Fig. 11. Now, measuring from the line RS in side view in Fig. 10, take the various distances to points of in-

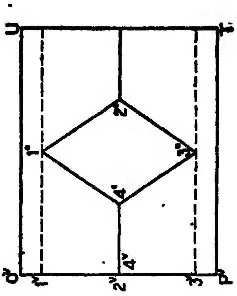


Fig. 11.

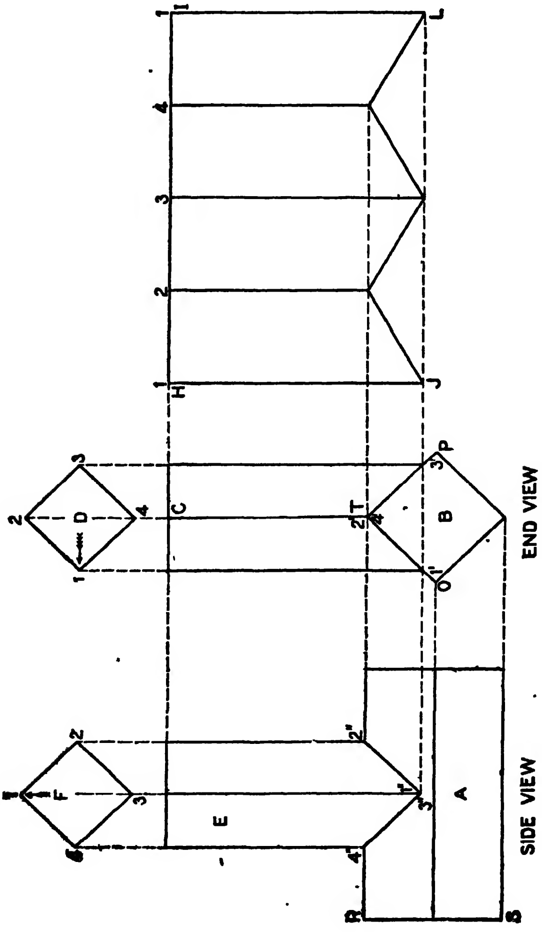


Fig. 10.

tersections 4″, 3″, 1″ and 2″, and place them in Fig. 11 on lines having similar numbers, measuring from the line $O^v P^v$, thus resulting in the intersections 1°, 2°, 3° and 4°. Connecting these points by lines as shown, then $O^v UTP^v$ will be the half development of the top of the horizontal prism. The bottom half will he similar without the opening.

Having described the principles relating to parallel forms, the next subject will be the principles relating to tapering forms. These forms include only the solid figures that have for a base the circle, or any of the regular polygons, also figures of unequal sides which can be inscribed in a circle, the lines drawn from the corners of which terminate in an apex, directly over the center of the base. The forms with which the tinsmith has to deal are more frequently frustums of these figures, and the method used in developing these surfaces is simply to develop the surface of the entire cone or pyramid, and then by simple measurements cut off part of the figure, leaving the desired frustum. Thus in the well-known forms of the dipper, coffee pot, colander, strainer, wash bowl, bucket, funnel, measure, pan, etc., we have the frustums of cones above referred to. In speaking here of metal plate articles as portions of cones, it must be remembered that all patterns are of surfaces, and as we are dealing with tinplate, these patterns when formed are not solids, but merely shells. In works upon Solid Geometry the right cone is defined as a solid with a circular base, generated by the revolution of a right-angle triangle about its vertical side called the axis.

This is more clearly shown in Fig. 12, in which is shown a right cone, which contains the principles applicable to all frustums of pyramids and cones. ABC represents the elevation of the cone; the horizontal section on the line BC being shown by GDEF, which is spaced into a number of equal parts, as shown by the small figures 1 to 12. As the center or apex of the cone is directly over the center *a* of the circle, then the length of each of the lines drawn from the small figures 1 to 12 to the center *a* will be equal both in plan and elevation. Therefore to obtain the envelope or development, use AB or AC as radius, and with A in Fig. 13 as center, describe the arc 1 – 1′. From 1 draw a line to A and starting from the point 1, set off on the arc 1 – 1′ the stretchout or num-

ber of spaces contained in the circle DEFG in Fig. 12, as shown by similar figures in Fig. 13. From 1′ draw a line to A. Then A – 1 – 7 – 1′ will be the development of the right cone of Fig. 12.

Suppose that a frustum of the cone is desired as shown by HICB, Fig. 12; then the opening at the top will be equal to the small circle in plan, and the radius for the pattern will be equal to AI. Now using A in Fig. 13 as a center with AI as radius, describe the arc HI, intersecting the lines 1A and A1′ at H and I respectively. Then H – I – 1′ – 7 – 1 will be the development for the frustum of the cone.

When a right cone is cut by a plane passed other than parallel to its base, the method of development is somewhat different. This

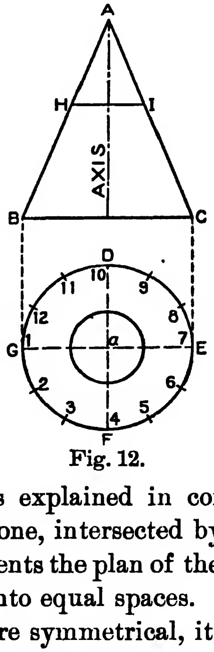


Fig. 12.

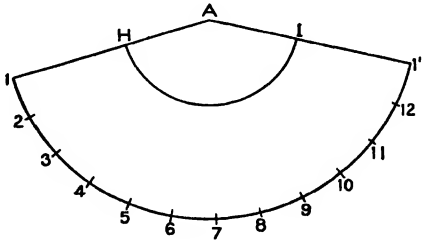


Fig. 13.

is explained in connection with Fig. 14, in which A is the right cone, intersected by the plane represented by the line DE. B represents the plan of the base of the cone, whose circumference is divided into equal spaces. As the intersection of both halves of the cone are symmetrical, it will be necessary to divide only half of plan B as shown by the small figures 1 to 7. From these points, erect lines parallel to the axis of the cone, intersecting the base line of the cone. From these points draw lines to apex F, intersecting the line DE as shown. From the intersections thus obtained on the line DE and at right angles to the axis, draw lines as shown, intersecting the side of the cone FE. Now using F as center and FH as a radius, describe the arc 7 – 7′. From 7 draw a line to F, and

starting from the point 7 set off on the arc $7-7'$, the stretchout of the circle B as shown by the small figures $7-1-7'$. From these points draw radial lines to the center point F, and intersect them by arcs struck from the center F, with radii equal to similarly numbered intersections on the side FH, and partly shown by points $7^v-1^v-7^\circ$. Trace a line through the points of intersections thus obtained; then $7^\circ-7^v-7-7'$ will be the desired development.

These same principles are applicable no matter at what angle the cone is intersected. For the section on the line DE, see the explanation in Mechanical Drawing Part III.

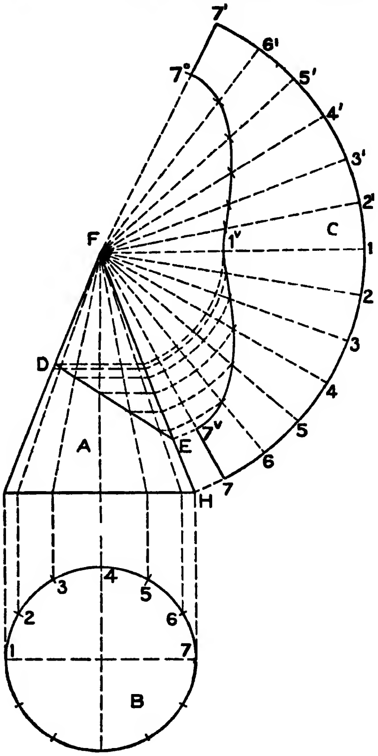


Fig. 14.

Fig. 15 shows the principles applicable to the developments of pyramids having a base of any shape. In this case, we have a square pyramid, intersected by the line DE. First draw the elevation of the pyramid as shown by ABC and in its proper position the plan view as shown by 1, 2, 3, 4. Draw the two diagonal lines $1-3$ and $2-4$ intersecting each other at A′. The length of the line AC represents the true length on A′*e*, but is not the correct radius with which to strike the development.

A true length must be obtained on the line A′4 as follows: At right angles to $3-4$ from the center A′ draw the line A′E′ and using A′ as center and A′4 as radius, describe the arc 4E′ intersecting A′E′ at E′. From E′ erect the perpendicular line $E'1^v$ intersecting the base line BC extended at 1^v. From 1^v draw a straight line to A, which will be the true length on A′4 and the radius with which to strike the development. (See also Part III, Mechanical Drawing) Now with A as center and $A-1^v$ as radius, describe the arc $1^v-3^v-1^v$. Starting

from 1^v set off the stretchout of 1 – 2 – 3 – 4 – 1 in plan, as shown by 1^v–2^v–3^v–4^v–1^v on the arc $1^v - 1^v$ ($1^v - 2^v$ being equal to 1 – 2, etc.), and from these points draw lines to the apex A and connect points by straight lines as shown from 1^v to 2^v, 2^v to 3^v, 3^v to 4^v and 4^v to 1^v. Then A1^v 3^v 1^v will be the development of the square pyramid.

To obtain the cut, in the development of the intersected plane

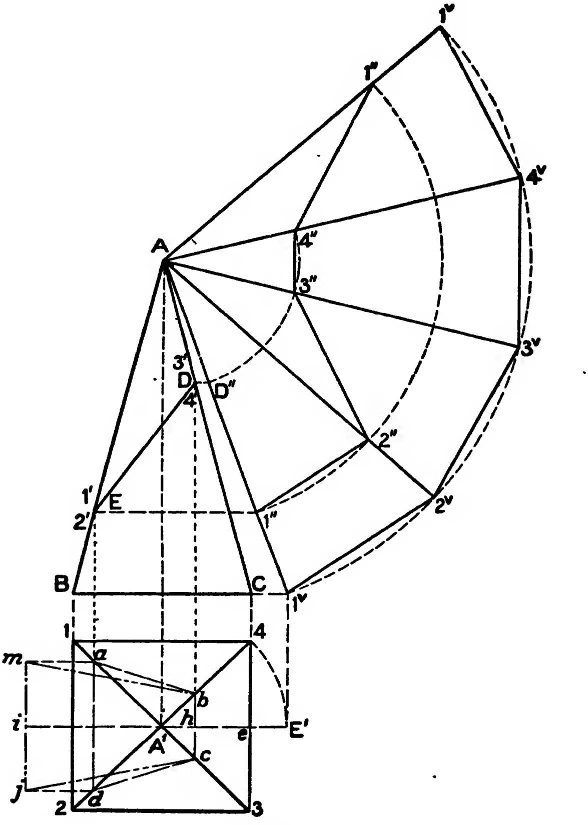


Fig. 15.

DE, which represents respectively the points $3^1 - 4^1$ and $1^1 - 2^1$, draw at right angles to the center line, the lines D – D'' and E–1'', intersecting the true length A1^v at D'' and 1''. Using A as center and radii equal to A – D'' and A – 1'' intersect similarly numbered radial lines in the development. Connect these points as shown

from 1″ to 2″, 2″ to 3″, 3″ to 4″ and 4″ to 1″. Then 1″ – 1^v – 3^v – 1^v – 1″ – 3″ will be the development of the intersected square pyramid.

To draw DE in plan drop perpendiculars from D and E intersecting the diagonal lines in plan at *b c* and *d a*. Connect lines as shown at *a*, *b*, *c* and *d*. To obtain the true section of the plane DE, take the length of DE and place it, as shown in plan from *h* to *i*; through *i* draw the vertical line *jm* which is intersected by horizontal lines drawn from points *a* and *d*. Draw a line from *b* to *m* and *c* to *j* which will be the desired section.

These problems just described should be thoroughly studied and practiced on paper, until every step is well understood.

Practical Workshop Problems will now be considered, and the student who thoroughly understands the principles explained in the foregoing problems, will be able to develop the patterns with greater ease and in less time than is required by the student, who pays little attention to the principles, but simply proceeds to develop the patterns by blindly following directions. A thorough knowledge of the principles renders the student independent as far as pattern problems are concerned, as he can apply them to new work.

Short Rules. There are various short rules, which, while not geometrically accurate, are sufficiently so for all practical purposes and will be introduced as we proceed. In developing patterns for any given article, the problem should be gone over carefully, locating the joints or seams, so that it can be seen, we might say in our minds' eye; by doing this a shorter rule may be employed, thus saving time and expense. The student who pays attention to these smaller details will succeed as a pattern draftsman.

Allowance for Seaming and Wiring. As we are dealing with tin plate only, we assume this to have no thickness, and therefore make no allowance for the shrinkage of the metal, when bending in the machine folder or brake.

The amount of the material to be added to the pattern for wiring wil vary according to the thickness of the metal. A safe and practical plan is to use a small strip of thin metal about $\frac{1}{4}$ inch wide and curl this around the wire which is to be used as shown in Fig. 16. This will give the true amount of material required, whether the wire is to be laid in by hand or by means of the wiring machine. First bend off with plyers a sharp corner as shown at *a*,

place the wire in the corner and turn A snugly around the wire as shown at B. The amount of A, or the allowance to be added to the height of the pattern is thus obtained. The vertical joint in tinware is usually a lock seam as shown in Fig. 17. Three times the width of the lock *a* must be added to the pattern. In other words, the end *b* has a single edge as *d*, while the other end *c* has a double edge as shown at *a* and *e*; the two ends of the body joining at *f*.

In allowing these edges for the pattern, some workmen prefer to add a single edge on one side of the pattern, and a double edge on the other, while others prefer to allow one-half of the amount required on either side of the pattern. Where the bottom of any piece of tinware is to be joined to the body, it is generally double

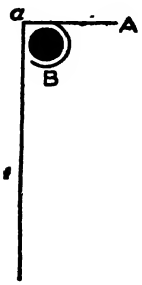


Fig. 16.

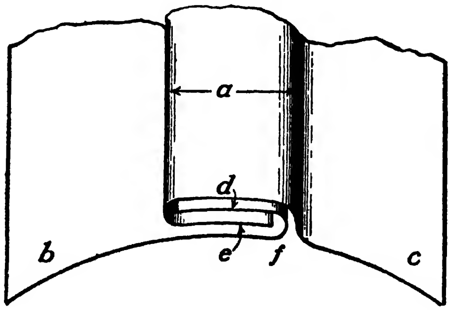


Fig. 17.

seamed as is shown in Fig. 18, where the two operations are clearly shown by A and B whether the seaming is done by hand or machine, while the lock seam in Fig. 17, is done on the groover.

Notching the Patterns. Another important point is the notching of the edges of the patterns for seaming and wiring; special attention should be given to this. The notches should be made in such a manner that when the article is rolled up and the wire encased or the seams grooved, the ends of the wire or seam allowance will fit snugly together and make a neat appearance. When an article is made and the notches have not been cut properly, the wire, or uneven lines, will show at the ends of the seam. Fig. 19 shows how the allowance for wire or locks should be cut. A shows the pattern to which an allowance has been made for wire at B and for seaming to the bottom at C. In this case a single edge D has been allowed at one end of the pattern

and a double edge of the other as shown at E. Then, using this method of allowance for seaming, notch the allowance for wire B and seam C on a line drawn through the solid lines in the pattern as shown by *aa* and *bb*. The notches of the allowance D and E should be cut at a small angle, as shown.

Transferring Patterns. After the pattern has been developed on manilla paper, which is generally used in the shop, it is placed on the tin plate and a few weights laid on top of the paper; then with a sharp scratch awl or prick punch and hammer, slight prick-punch marks are made, larger dots indicating a bend. The paper is then removed and lines scribed on the plate, using the scratch awl for marking the straight lines, and a lead pencil for the curved lines. After laps are added as required, it is ready to be cut out with the shears.

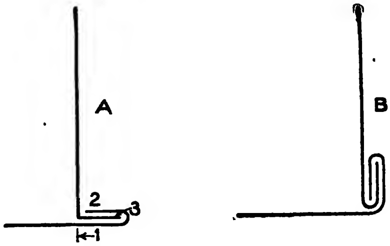


Fig. 18.

PRACTICAL PROBLEMS.

In presenting the twelve problems which follow, particular attention has been given to those problems which arise in shop practice. These problems should be practiced on cheap manilla paper, scaling them to the most convenient size, and then proving them by cutting the patterns from thin card board, and bending or forming up the models. This will prove both instructive and interesting.

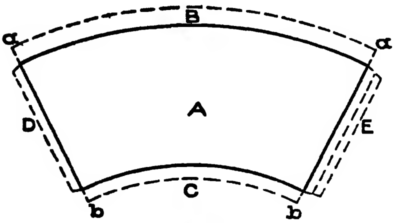


Fig. 19.

Pail. The first piece of tinware for which the pattern will be developed is that known as the flaring bucket, or pail, shown in Fig. 20. First draw the center line AB, Fig. 21, upon which place the height of the pail, as shown by CD. On either side of the center line place the half diameters CE of the top and DF of the bottom. Then EFFE will be the elevation of the pail. Extend the lines EF until they meet the center line at B, which will

be the center point with which to describe the pattern. Now, with C as center and CE as radius, describe the semi-circle EAE, and divide it into equal spaces, as shown. This semi-circle will represent the half section of the top of the pail.

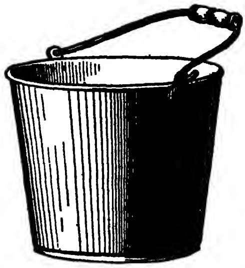


Fig. 20.

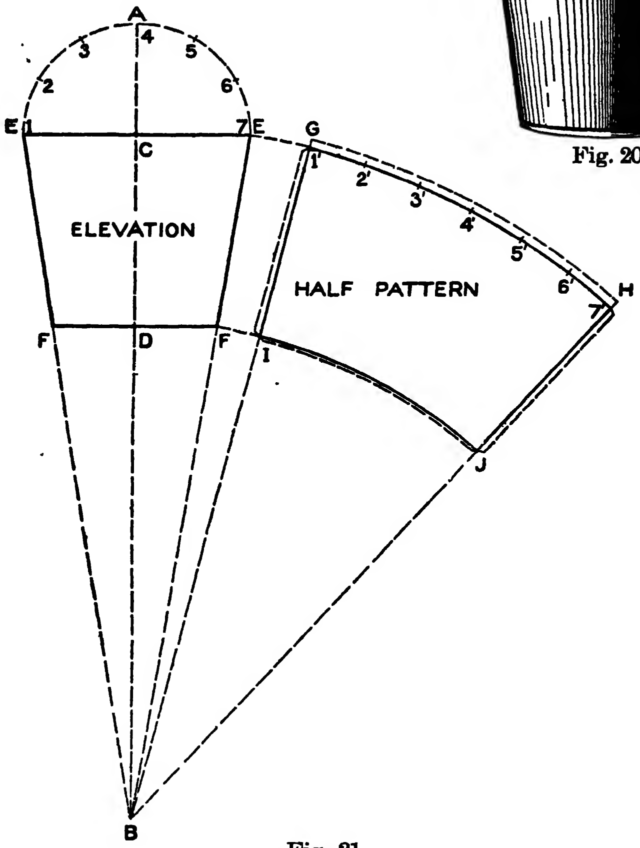
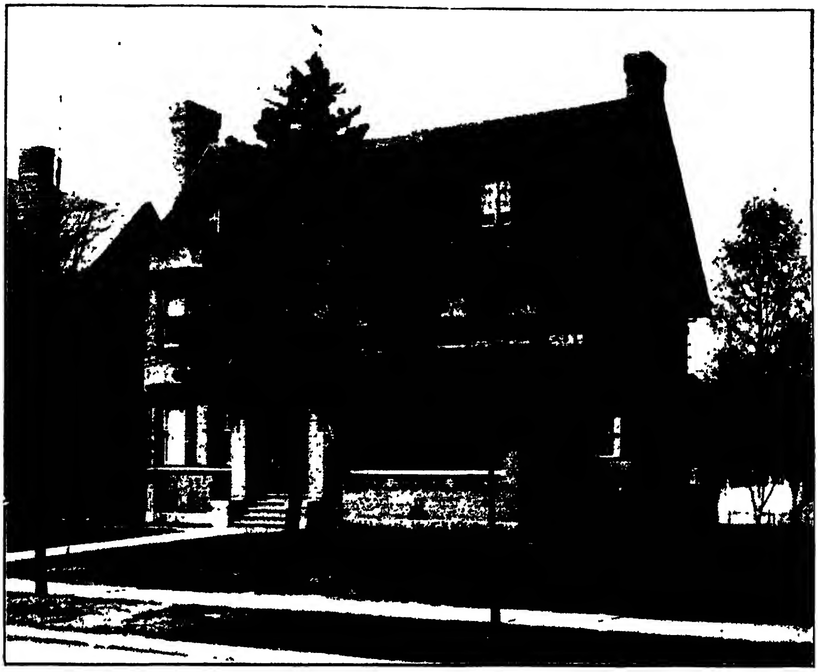
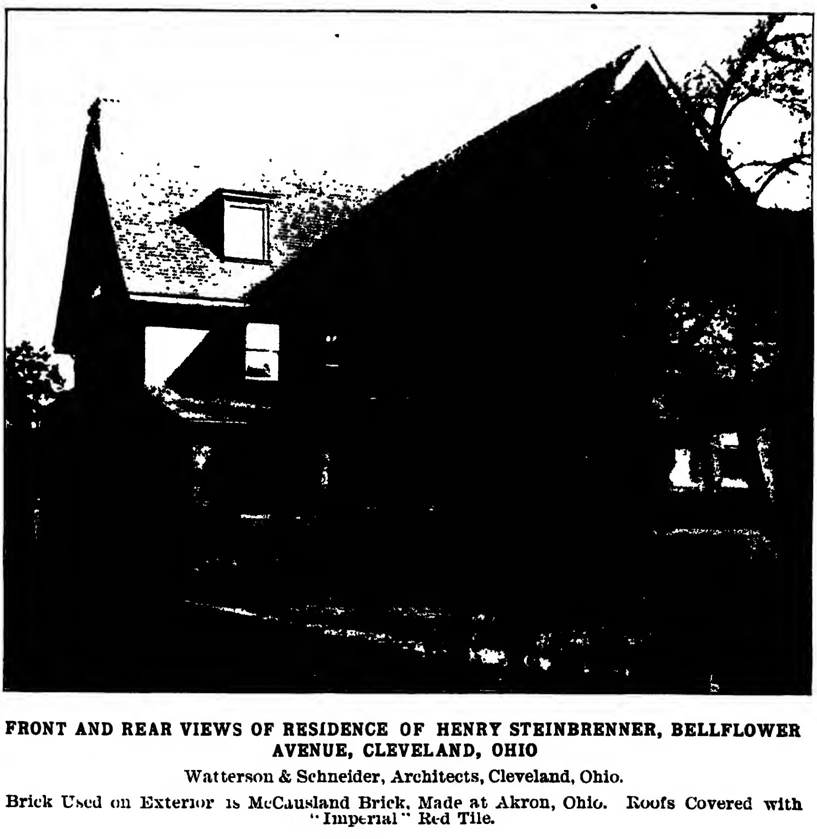


Fig. 21.

For the pattern proceed as follows: With B as center and radii equal to BF and BE, describe the arcs GH and IJ. Draw a line from G to B. Starting from the point G lay off on the arc GH, the stretchout of the semi-circle EAE, as shown by similar figures on GH. From H draw a line to B, intersecting the arc IJ at J. Then GHJI will be the half pattern for the pail, to which laps must be added for seaming and wiring as shown by the dotted lines.





FRONT AND REAR VIEWS OF RESIDENCE OF HENRY STEINBRENNER, BELLFLOWER AVENUE, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

Brick Used on Exterior is McCausland Brick, Made at Akron, Ohio. Roofs Covered with "Imperial" Red Tile.

Funnel and Spout. In Fig. 22 is shown a funnel and spout, which is nothing more than two frustums of cones joined together.

Fig. 23 shows how the patterns are developed. In this figure the full elevation is drawn, but in practice it is necessary to draw only one-half of the elevation, as shown on either side of the center

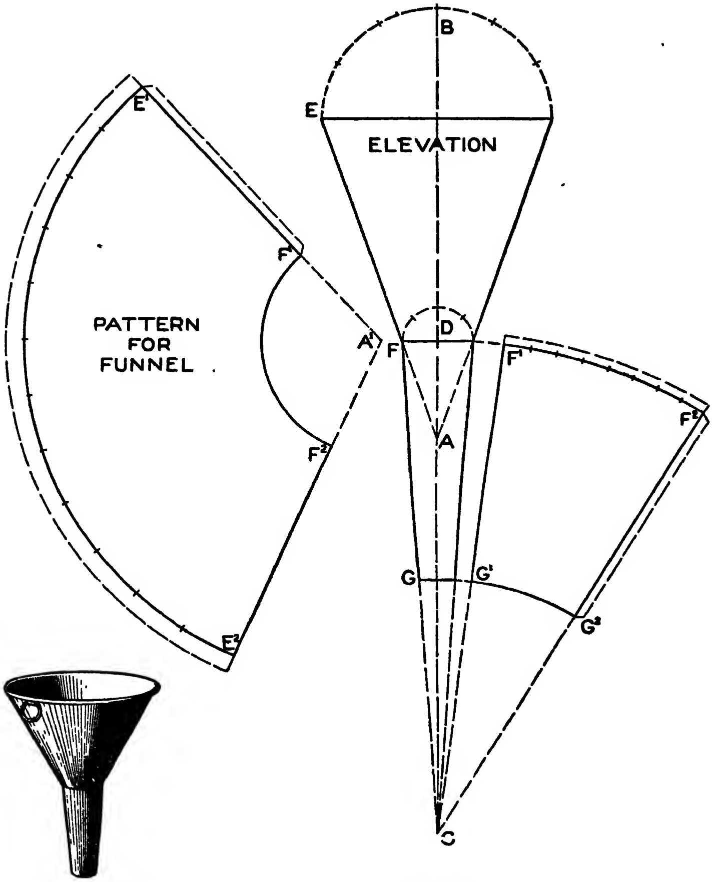


Fig. 22.

Fig. 23.

line BC. Extend the contour lines until they intersect the center line at C and A. Now, using A^1 as a center, with radii equal to AF and AE, describe the arcs F^1F^2 and E^1E^2 respectively. On the arc E^1E^2 lay off twice the number of spaces contained in the semi-circle B, then draw radial lines from E^1 and E^2 to A^1, intersecting the inner arc at F^1F^2, which completes the outline for the

pattern. Laps must be allowed for wiring and seaming. For the pattern for the spout use C as a center, and with radii equal to CG and CF describe the arcs F^1F^2 and G^1G^2. On F^1F^2 lay off twice the amount of spaces contained in the semi-circle D, and draw radial lines from F^1 and F^2 to C. Then $F^1F^2G^1G^2$ will be the pattern for the spout. The dotted lines show the edges allowed.

Hand Scoop. In Fig. 24 is shown a perspective view of a hand scoop, in the development of which the parallel and radial line developments are employed. Thus A and B represent intersected cylinders, while C represents an intersected right cone. The method of obtaining the patterns for the hand scoop is clearly shown in Fig. 25; these principles are applicable to any form of hand scoop.

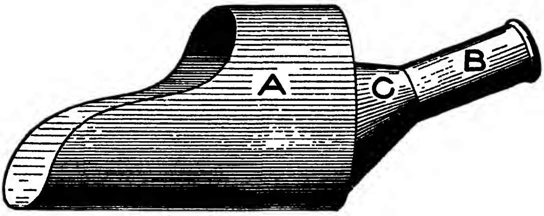


Fig. 24.

First draw the side view of the scoop as shown, in line with which place the half section; divide this into a number of equal spaces as shown by the figures 1 to 7. From these points draw horizontal lines intersecting the curve of the scoop. In line with the back of the scoop draw the vertical line 1–1′, upon which place the stretchout of twice the number of spaces contained in the half section, as shown by similar numbers on the stretchout line. From these points on the stretchout line draw horizontal lines, which intersect lines drawn from similarly numbered points on the curve of the scoop parallel to the stretchout line. Trace a line through points thus obtained, which will give the outline for the pattern for the scoop, to which edges must be allowed as shown by the dotted line. The pattern for the back of the scoop is simply a flat disc of the required diameter, to which edges for seaming are allowed.

When drawing the handle, first locate the point at which the center line of the handle is to intersect the back of the scoop, as at 2°. Through this point, at its proper or required angle, draw the center line $2^{\circ}2^{x}$. Establish the length of the handle, and with any point on the center line as center, draw the section

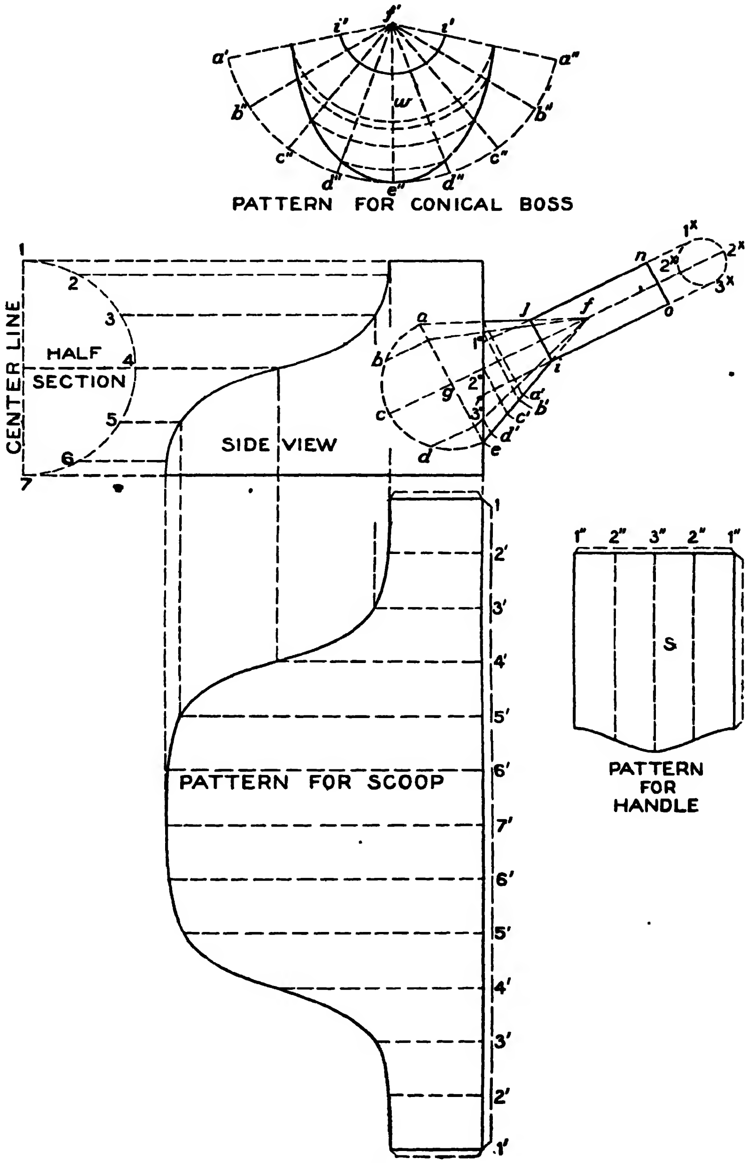

PATTERN FOR CONICAL BOSS
CENTER LINE
HALF SECTION
SIDE VIEW
PATTERN FOR SCOOP
PATTERN FOR HANDLE

Fig. 25.

as shown by 1^x, 2^x 3^x, and 2^x, and divide the circumference into equal spaces, in this case four. (In practical work it would be better to use more than four). Parallel to the center line and from these four divisions draw lines as shown intersecting the back of the scoop at 1°, 2° and 3°. For the pattern draw any horizontal line in S, as 1″3″1″, upon which place the stretchout of the section of the handle as shown by 1″ 2″ 3″ 2″ 1″ on the stretchout line. From these points at right angles to the line of the stretchout, draw lines as shown. Take the various distances measuring from the line *no* in side view to points 1°, 2° and 3°, and place them on lines drawn from similar numbers in S, measuring from the line 1″3″1″. A line traced through these points of intersection will be the pattern for the handle, laps being indicated by dotted lines. To close the top of the handle *no*, a small raised metal button is usually employed, which is double-seamed to the handle.

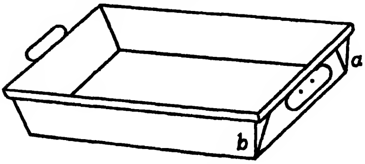


Fig. 26.

To draw the conical boss in side view, first locate the points *i* and *e*, through which draw a line intersecting the center line of the handle at *f*. At right angles to the center line, draw the line *ij* representing the top opening of the boss. In similar manner, at right angles to the center line, draw a line from *e* as shown by *ea*, intersecting the center line at *g*. Now make *ga* equal to *ge* and draw a line from *a* to the center *f*, which will intersect the back of the scoop as shown and the top of the boss at *j*. With *g* as center and *ga* as radius describe the half section of the cone, divide this into equal spaces as shown by *abcde*, from which draw lines at right angles to and intersecting the base of the cone *ae* as shown. From the intersections on the base line draw radial lines to the apex *f*, intersecting the back of the scoop as shown. From these intersections at right angles to the center line, draw lines intersecting the side of the boss at *a′b′c′d′*. For the pattern proceed as shown in diagram *w*. With radius equal to *fe* in the side view and *f′* in *w*, as a center describe the arc *a′a″*. Draw a line from *a″* to the center *f′*, and starting from *a″* set off on the arc *a′a″* twice the number of spaces contained in the semi circle *ace* in side view, as shown by similar letters in diagram *w*. From these points

draw radial lines to the center f. Now using f in w as a center describe the arc $i'i'$. In similar manner, using as radii fa', fb', fc', fd' and fe in side view, and f in w as center, describe arcs intersecting radial lines having similar letters as shown. A line traced through points thus obtained forms the pattern for the conical boss.

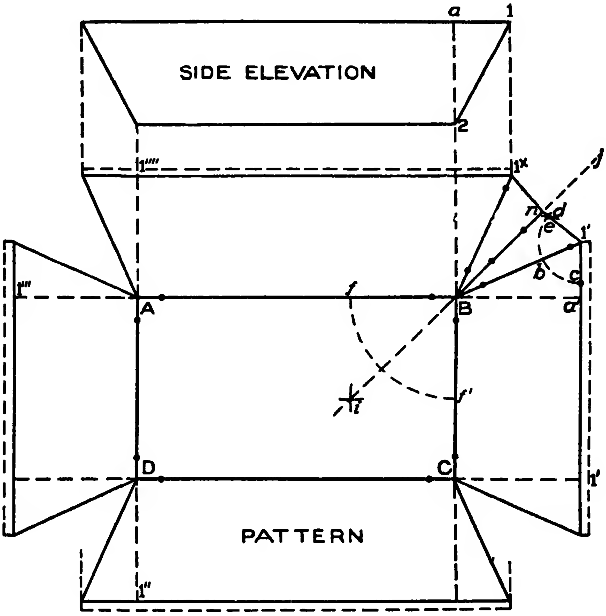


Fig. 27.

Drip Pan. Fig. 26 shows a view of a drip pan with beveled sides. The special feature of this pan is that the corners a and b are folded to give the required bevel and at the same time have the folded metal come directly under the wired edge of the pan. A pan folded in this way gives a water tight joint without any soldering. Fig. 27 shows the method of obtaining the pattern when the four sides of the pan have the same bevel. First draw the side elevation having a bevel indicated at a21. Now draw ABCD, a rectangle representing the bottom of the pan. Take the distance of the slant 1 – 2 in elevation and add it to each side of the rectangular bottom as shown by 1′, 1″, 1‴ and 1⁗. Through these points draw lines parallel to the sides of the bottom as shown. Now extend the lines of the bottom AB, BC, CD and DA intersecting the lines just drawn. Take the projection of the bevel

a to 1 in side elevation and place it on each corner of the pan, as, for example, from *a'* to 1'. Draw a line from 1' to B. By proceeding in this manner for all the corners, we will have the butt miters, if the corners were to be soldered raw edge. Where the bevels are equal on all four sides, the angle $1^x B 1'$ is bisected as

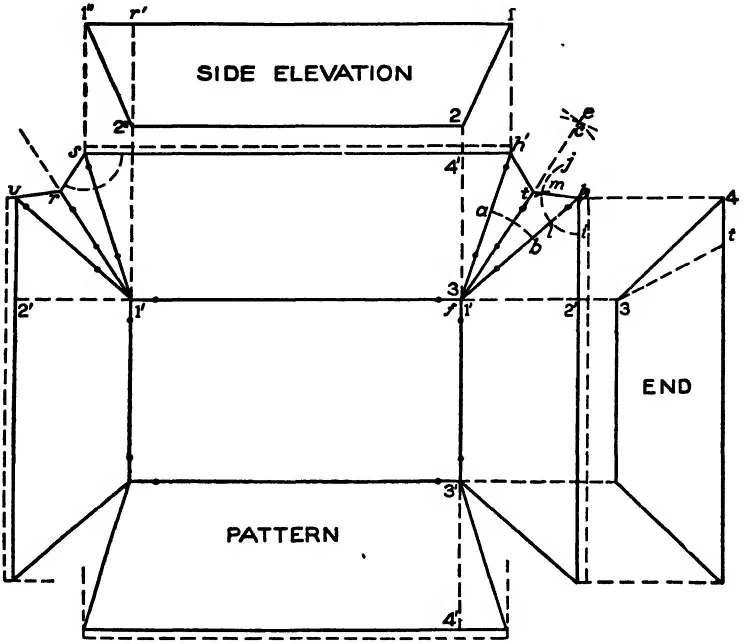


Fig. 28.

follows: With B as center and any radius draw the arc *ff'* intersecting the sides of the bottom as shown. Then with a radius greater than one half of *ff'*, with *f* and *f'* respectively as centers, draw arcs which intersect each other at *i*. Draw a line through the intersection *i* and corner B, extending it outward toward *j*.

Now with 1' as center, and radius less than one-half of $1' - 1^x$, draw arc *d–c*, intersecting the line 1' B at *b*, and intersecting the line 1'*a'* at *c*. Then with *b* as center and *bc* as radius, intersect the arc *cd* at *e*. Draw a line from 1' to *e*, intersecting the line *ij* at *n*. From *n* draw a line to 1^x. Transfer this cut to each of the corners, which will complete the pattern desired. Dotted lines indicate the wire allowance.

Sometimes a drip pan is required whose ends have a different

flare from those of the sides, and in one case the folded corners are to be bent toward the end, while it may be required that the corners be folded towards the side. The principles are similar in both cases, but as the method of applying these principles may be a little difficult, Fig. 28 has been prepared, which will explain the application of these principles.

First draw the side elevation, showing the desired flare; also draw the end elevation, which shows the flare of the sides, being careful that the vertical heights in both views are the same. Now draw the pattern of the pan as follows: Take the distance 1–2 in side elevation and place it on the ends of the bottom as shown on either side by 1′–2′. Similarly take the distance 3–4 in end elevation and place it on the sides of the bottom as shown on either side by 3′–4′. Through the point 2′ and 4′ draw lines parallel to the ends and sides of the bottom as shown, which intersect lines dropped from the end and side views respectively. *hfh′* represent the butt miters which should be placed on all corners. If these miters have been correctly developed, the lengths from *h* to *f* must be equal to *fh′*. Bisect the angle *hfh′* by using *f* as center and drawing the arc *ab*, then use *a* and *b* as centers and obtain the intersection *c*, through which draw the line *ef*. Now assume that the folded corner is to be turned towards the end view as shown by *t*3. Using *h* as a center draw the arc *ij*. Then with *l* as center and *li* as radius, intersect the arc *ij* at *m*. Draw a line from *h* through *m*, meeting the line *ef* at *t*, and draw a line from *t* to *h′*.

If the folded corner were turned towards the side as shown by *r′*–2″ in the side view, bisect the angle *v*1′*s* as before, and use *s* as a center and proceed as already explained. Note the difference in the two corners. The only point to bear in mind is, that when the corner is to be folded towards the end, transfer the angle of the end miter; while if the corner is to be turned towards the side, transfer the angle of the side miter. If the corners were to be folded toward the ends of the pan, the cut shown in the right-hand corner would be used on all four corners, while if the corners were to be folded towards the sides, the cut shown on the left-hand corner would be used.

Tea Pot. In Fig. 29 is shown the well-known form of the tea or coffee pot, for which a short method of developing the pat-

tern is shown in Fig. 30. This is one of the many cases where a short rule can be used to advantage over the geometrical method. While it is often advisable to use the true geometrical rule, the difference between that and the method here shown is hardly noticeable in practice. Of course, if the body A and spout B were larger than the ordinary tea pots in use, it would be necessary to use the true geometrical rule, which is thoroughly explained for Plates I, II and III.

Fig. 29.

The pattern for the body of the tea pot will not be shown, only the short rule for obtaining the opening in the body to admit the joining of the spout. The method of obtaining the pattern for the body is similar to the flaring vessels shown in previous problems.

First draw the elevation of the body of the tea pot as shown at A. Assume the point *a* on the body and draw the center line of the spout at its proper angle as shown by 2*b*. Establish the point 3 of the bottom of the spout against the body, also the point 3^x at the top and draw a line from 3 through 3^x intersecting the center line at *b*. At right angles to the center line and from 3 draw the line 3 – 1 and make *c*1 equal to *c*3. From 1 draw a line to the center point and from 3^x draw a horizontal line until it intersects the opposite side of the spout at 1″. Then 1′ – 1″ – 3^x–3 will be the side view of the spout. Now with *c* as a center draw the half section 1–2–3 and divide it into equal spaces; in this case but two (in practical work more spaces should be employed). From these points and at right angles to 1 – 3 draw lines intersecting the base of the spout as shown, and draw lines from these points to the center *b*. Thus line 1*b* intersects the body at 1′ and the top of the spout at 1″; line 2*b* intersects the body at *a* and the top of the spout as shown, while line 3*b* cuts at 3 and the top of spout at 3^x. From these intersections at right angles to the center line *ab*, draw lines intersecting the side of the spout at 3, 2°, 1° at the bottom and 1^x, 2^x, 3^x at the top. Now with *b* as center and *b*3 as radius, describe the arc 3″ – 3″ upon which place the stretchout of twice

the number of spaces contained in the half section 1 – 2 – 3, as shown by similar figures on 3″ – 3″; from these points draw radial lines to the center *b*, and intersect them by arcs drawn with *b* as a center and radii equal to the intersections contained on the side of

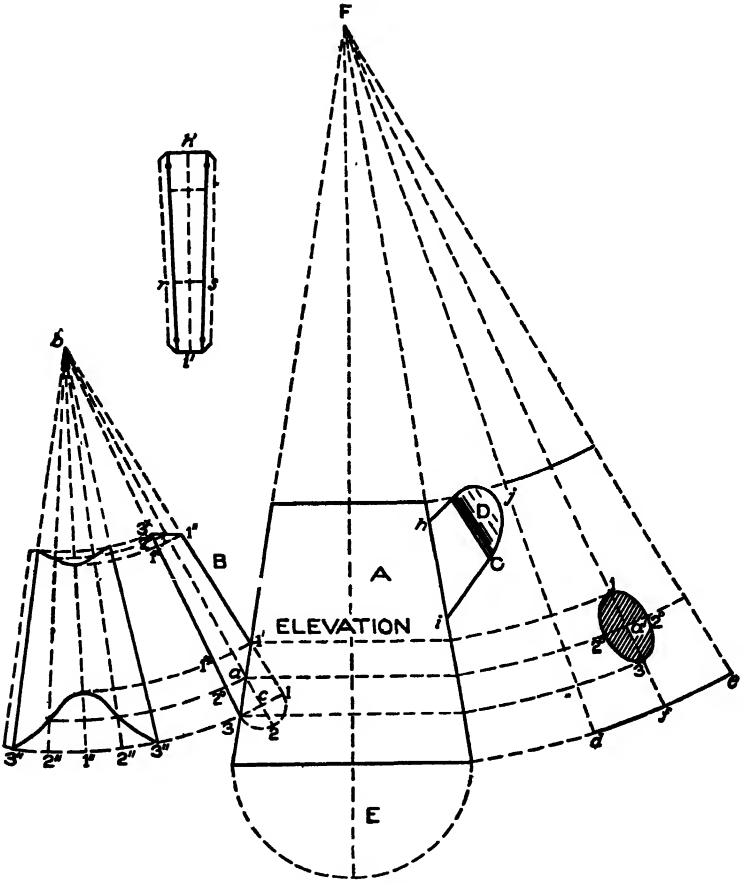


Fig. 30.

the spout 3 – 3ˣ. To form the pattern, trace a line through points thus obtained and make the necessary allowance for edges.

It should be understood that in thus developing the spout, the fact that the spout intersects a round surface has not been considered; it was assumed to intersect a plane surface. As already stated the difference in the pattern is so slight that it will not be noticeable

in practice. Had we developed the pattern according to the true geometrical rule, it would present a problem of two cones of unequal diameter intersecting each other, at other than at right angles to the axes.

For the pattern for the opening in the body, draw lines at right angles to the center line of the body from intersections 1′, *a* and 3 intersecting the opposite side of the body as shown. With F as a center draw a partial pattern of the body as shown by *de*. From any point *f* draw a line to the center F. Now with F as center draw the arcs 1, 2° and 3. The distance 1 to 3 on the line F*f* represents the length of the opening, while a line drawn through *a* at right angles to the center line *bc* of the spout represents the width of the opening. Therefore take the distance from *a* to 2° and place it as shown from *a*′ on the line *f*F to 2°–2° on either side on the arc. Trace an ellipse through 1–2°–3–2° for the shape of the opening.

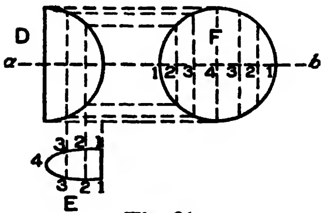


Fig. 31.

The pattern for the handle is obtained by taking the stretchout of *hji* and placing it as shown on the vertical line *h′i′*. At right angles to *h′i′* on either side, at top and bottom add the desired width of the handle and draw the lines shown; add edges for wiring or hem edge.

For the pattern for the grasp D which is placed inside on the handle proceed as is shown in Fig. 31. Let D represent an enlarged view of part of the handle in which the grasp is to be soldered. Directly in line with it draw the section E taking care that the width from 1 to 1 will not be wider than that portion of the handle from *r* to *s* in Fig. 30, being the width at C in the elevation. Divide the section E in Fig. 31 into a number of equal spaces, from which draw vertical lines intersecting the curve D as shown. Draw the center line *ab* upon which lay off the stretchout of E as shown by similar figures. Through these points draw lines which intersect with lines drawn from similar intersections in the curve D parallel to *ab*. Trace a line through the points thus obtained as shown at F.

Foot Bath. In Fig. 32 is shown an oval foot bath; the principles used in obtaining the pattern of which are applicable to any

form of flaring vessels of which the section is elliptical or struck from more than two centers. In this connection it may be well to explain how to construct an ellipse, so that a set of centers can be obtained with which to strike the arcs desired. Fig. 33 shows the method of drawing an approximate ellipse, if the dimensions are given. Let AB represent the length of the foot bath and CD its width. On BA measure BE equal to CD. Now divide the distance EA into three equal parts as shown by 1 and 2. Take two of these parts as a radius, or E2, and with O as center, describe arcs intersecting the line BA at X and X^1. Then with XX^1 as a radius and using X and X^1 as centers describe arcs intersecting each other at C and D. Draw lines from C to X and X^1 and extend them toward F and G respectively. Similarly from D draw lines through X and X^1, extending them towards I and H respectively. Now with X and X^1 as centers, and XA and X^1B as radii describe arcs intersecting the lines ID, FC, GC and HD at J, K, L and M, respectively. In similar manner

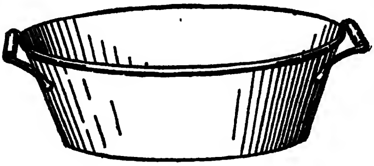


Fig. 32.

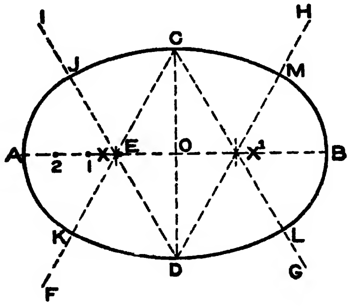


Fig. 33.

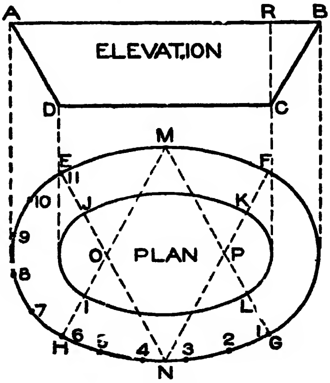


Fig. 34.

with D and C as centers and DC and CD as radii describe arcs which must meet the arcs already drawn at J, M, L and K, respectively, forming an approximate ellipse. In Fig. 34 let ABCD represent the side elevation of the pan, whose vertical height is equal to RC.

In precisely the same manner as described in Fig. 33 draw

the plan as shown, in correct relation to the elevation, letting EFGH be the plan of the top of the pan, and JKLI the plan of the bottom, struck from the centers, O,M,P and N. The next step is to obtain the radii with which to strike the pattern. Draw a horizontal line RE in Fig. 35 equal in length to NE in plan in Fig 34. Take the vertical height RC in elevation, and place it as shown by RC in Fig. 35 on a line drawn at right angles to RE. Parallel to RE and from the point C, draw the line CJ equal to NJ in Fig. 34.

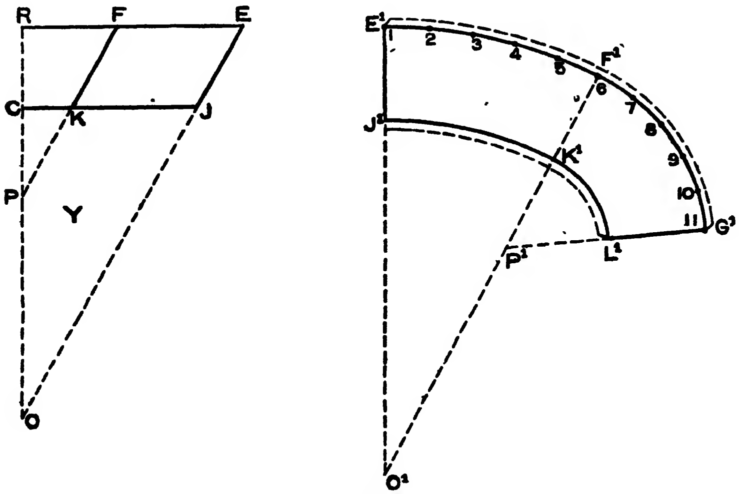


Fig. 35.

Now draw a line from E to J in Fig. 35, extending it until it meets the line RC produced. Then OJ and OE will be the radii with which to make the pattern for that part of the pan or foot bath shown in plan in Fig. 34 by EFKJ and GHIL.

To obtain the radii with which to strike the smaller curves in plan, place distances PF and PK on the lines RE and CJ in Fig. 35 as shown by RF and CK. Draw a line from F through K until it meets the line RO at P. Then PK and PF will be the radii with which to strike the pattern, for that part shown in plan in Fig. 34 by KFGL and IHEJ. Now divide the curve from G to H and H to E (Fig. 34) into a number of equal spaces. To describe the pattern draw any vertical line E^1O^1 (Fig. 35) and with O^1 as center and radii equal to OJ and OE in the diagram Y, describe the arcs J^1K^1 and E^1F^1 as shown. On the arc E^1F^1 lay off the stretch-

out of GH in plan in Fig. 34 as shown by similar figures in Fig. 35. From the point 6 on the arc E^1F^1 draw a line to O^1 intersecting the curve J^1K^1. Now with PF in diagram Y as radius and F^1 as a center describe an arc intersecting the line F^1O^1 at P^1. Then using P^1 as a center and with radii equal to P^1K^1 and P^1F^1 describe the arcs K^1L^1 and F^1G^1 as shown. On the arc F^1G^1 starting from point 6 lay off the stretchout of HE, Fig. 34. From 11 draw a line to P^1 intersecting the arc K^1L^1 at L^1. Then $E^1F^1G^1L^1K^1J^1$ will be the

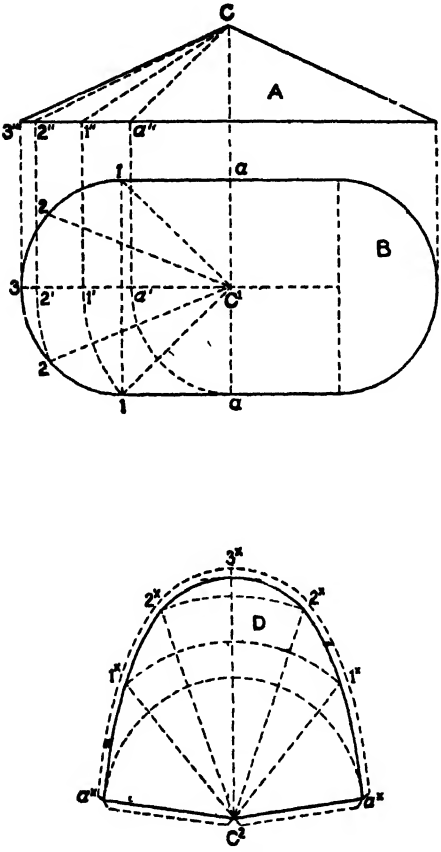


Fig. 37.

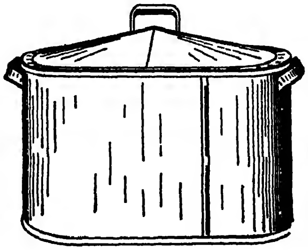


Fig. 36.

half pattern, the allowance for wiring and seaming being shown by the dotted lines.

Should the article be desired in four sections, two pieces of $F^1K^1L^1G^1$ would be required. The pattern for the bottom of the pan is shown by the inner ellipse in Fig. 34 to which of course edges must be allowed for double seaming.

Wash Boiler. In Fig. 36 is shown a perspective view of a wash boiler to which little attention need be given, except to the raised cover. First draw the plan of the cover B, Fig. 37, which shows straight sides with semi-circular ends. In line with the plan draw the elevation A, giving the required rise as at C. Let C represent the apex in elevation, and C^1 the apex in plan. As both

halves of the cover are symmetrical, the pattern will be developed for one half only. Divide the semi-circle 1 – 3 – 1 into a number of equal spaces as shown by the small figures 1, 2, 3, 2 and 1. From these points draw radial lines to the apex C^1, and through C^2 draw the perpendicular *aa*. C3″ in elevation represents the true length of $C^1 3$ in plan, and to obtain the true length of $C^1 2$, $C^1 1$ and $C^1 a$, it will be necessary to construct a diagram of triangles as follows: With C^1 as center, and $C^1 a$, $C^1 1$ and $C^1 3$ as radii, describe arcs intersecting the center line in plan at a', 1′ and 2′. From these points at right angle to $3C^1$ erect lines intersecting the base line of the elevation at a'', 1″, 2″ and 3″, from which draw lines to the apex C, as shown. Now, with radii equal to C3″, C2″, C1″ and Ca'', and C^2 as center describe arcs 3^x,$2^x 2^x$, $1^x 1^x$ and $a^x a^x$. From C^2 erect the perpendicular intersecting the arc 3^x at 3^x. Now set the dividers equal to the spaces 3 to 2 to 1 to *a* in plan, and starting from 3^x step off to similar numbered arcs, thus obtaining the intersections $2^x 1^x a^x$; from a^x draw lines to C^2, and trace a line $a^x 3^x a^x$ to get the half pattern for the cover. Allow edges for seaming.

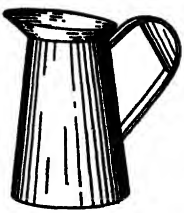


Fig. 38.

The body of the boiler requires no pattern, as that is simply the required height, by the stretchout of the outline shown in plan. The handles shown on the body and cover in Fig. 36 are plain strips of metal to which wired or hem edges have been allowed.

Measure. Fig. 38 shows a flaring-lipped measure with handle attached. Care should be taken in laying out the patterns for these measures, that when the measure is made up it will hold a given quantity. While there are various proportions used in making up the size of the measure, the following table gives good proportions:

Quantity.	Bottom Diameter in inches.	Top Diameter in inches.	Height.
1 Gill.	2.06	1.37	3.10
½ Pint.	2.60	1.75	3.89
1 Pint.	3.27	2.18	4.90
1 Quart.	4.12	2.75	6.18
½ Gallon.	5.18	3.45	7.78
1 Gallon.	6.55	4.35	9.80

Fig. 39 shows the method of laying out the pattern for the measure and lip. First draw the elevation A to the desired size

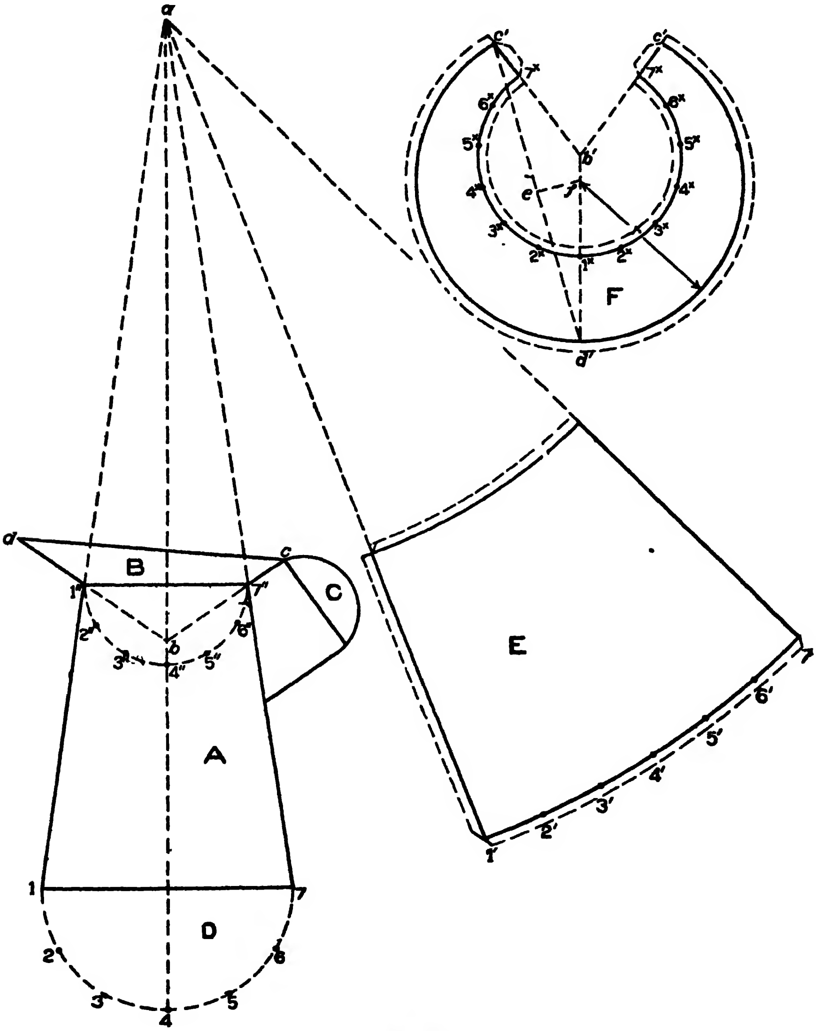


Fig. 39.

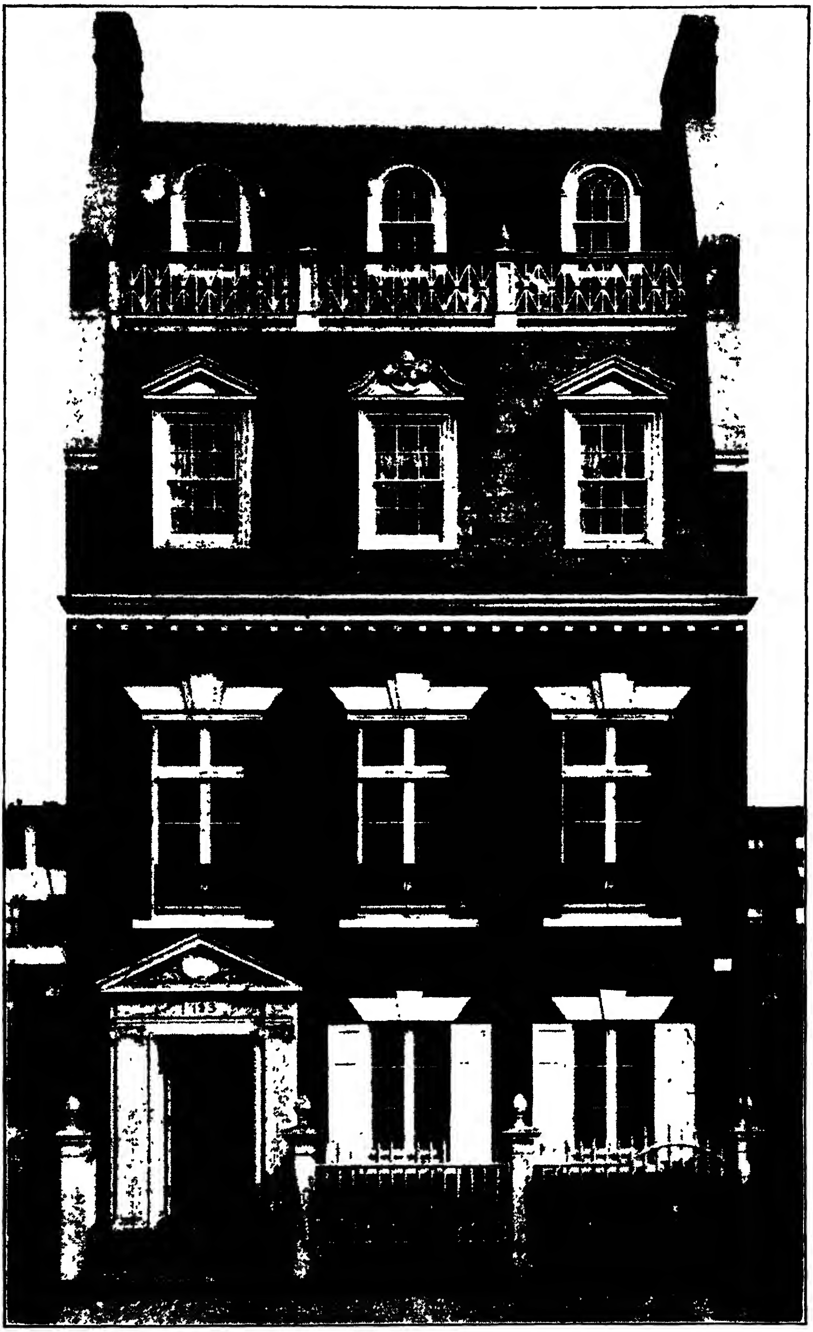
and assume the flare of the lip B, as shown by *db*. From *b* draw a line through 7″ to *c* which is a chosen point, and draw a line from *c* to *d*. Draw the handle C of the desired shape. Now extend contour lines of the measure until they intersect at *a*, and draw

the half section of the bottom of the measure as shown at D; divide this semi-circle into equal parts as shown. Now, with a as a center, and $a7$ and $a7''$ as radii, describe the arcs as shown. From any point (as 1′) draw a radial line to a, and starting at 1′ set off the number of spaces contained in the half section D, as shown by the small figures 1′ to 7′. From 7′ draw a radial line to a. Allow edges for wiring and seaming. E represents the half pattern for the body of the measure. We find that lip B is simply an intersected frustum of a right cone, which can be developed as shown in the pattern for conical boss of Fig. 25.

There is, however, a shorter method which serves the purpose just as well; this is shown at F, Fig. 39. First draw the half section of the bottom of the lip, which will also be the half section of the top of the measure, as shown by the figures 1″ to 7″. Now, with radii equal to $b-1''$, or $b-7''$ and b' in F as center, describe the arc 7^x7^x. From b' drop a vertical line intersecting the arc at 1^x. Starting from the point 1^x, set off the spaces contained in the half section 1″–4″–7″, as shown by the figures 1^x to 7^x. From b' draw lines through the intersections 7^x7^x, extending them as shown. Now take the distance from 1″ to d of the front of the lip and place it as shown by $1^xd'$ in F. In similar manner take the distance from 7″ to c of the back of the lip and place it as shown in F from 7^x to c' on both sides. Draw a line from c' to d', and bisect it to obtain the center e. From e, at right angles to $c'd'$, draw a line intersecting the line $b'd'$ at f. Then using f as center, with radius equal to fd', draw the arc $c'd'c'$, as shown. Adding laps for seaming and wiring will complete the pattern for the lips.

The pattern for the handle and grasp C is obtained as shown in Figs. 30 and 31.

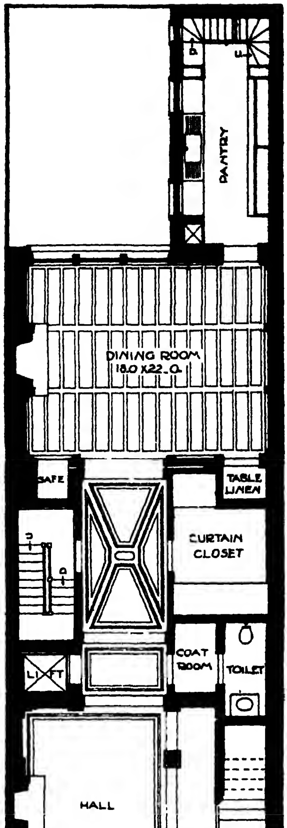
Scale Scoop. Fig. 40 shows a scale scoop, wired along the top edges and soldered or seamed in the center. The pattern is made as shown in Fig. 41. First draw the elevation of the scoop as shown by ABCD. (In practice the half elevation, BDC, is all that is necessary.) At right angles to BD and from the point C, draw the indefinite straight line CE, on which a true section is to be drawn. Therefore, at right angles to CE, from points C and E, draw the lines CC and EE^1. From E^1 erect a perpendicular as E^1C, on which at a convenient point locate the center F; with



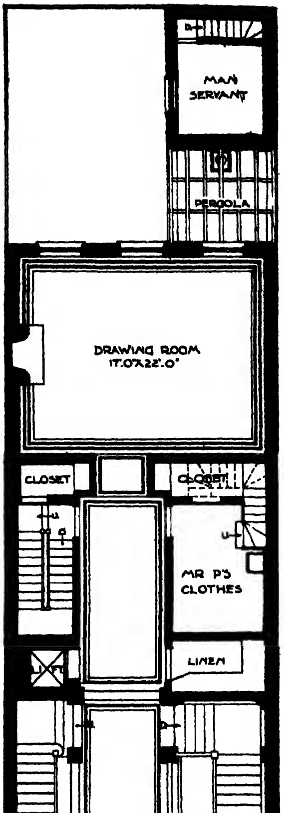
HOUSE AT 123 EAST 73d STREET, NEW YORK CITY

R. Burnside Potter, of Robertson & Potter, Architect, New York.

Front of A. B. C. Brick. Door and Fence, Wood, Painted; Walls and Lintels, Cremo Marble; Cornice and Dormers, Copper, Painted; Roofs of Slate. Cost, about $70,000. An Excellent Example of a Simple, Dignified Treatment for a Narrow City Lot. The Treatment of the Roof, to Give a Low Effect, is Particularly Good. For Plans, See Opposite Page.



GROUND FLOOR.



FIRST FLOOR.

PLANS OF HOUSE AT 123 EAST 73d STREET, NEW YORK CITY

R. Burnside Potter, of Robertson & Potter, Architect, New York.

Finish Floors from Ground to First Floor, Teak; above that, North Carolina Pine. Drawing Room Paneled Completely in Wood, Painted; and Walls throughout Rest of House Hung in Silk and Other Materials. Front View of House Exterior Shown on Opposite Page.

FE^1 as radius, describe the arc HE^1I. Then HE^1I will be the true section on CE in elevation. Divide the section into a number of equal parts as shown by the figures 1 to 7; through these points, parallel to the line of the scale BD, draw lines intersecting BC and CD as shown. At right angles to BD draw the stretchout line 1 – 7 and place upon it the stretchout of the section as shown by similar figures. At right angles to 1 – 7 draw lines which intersect lines drawn at right angles to BD, from intersections on BC and DC having similar numbers. Trace a line through these

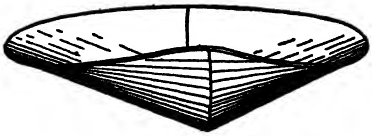


Fig. 40.

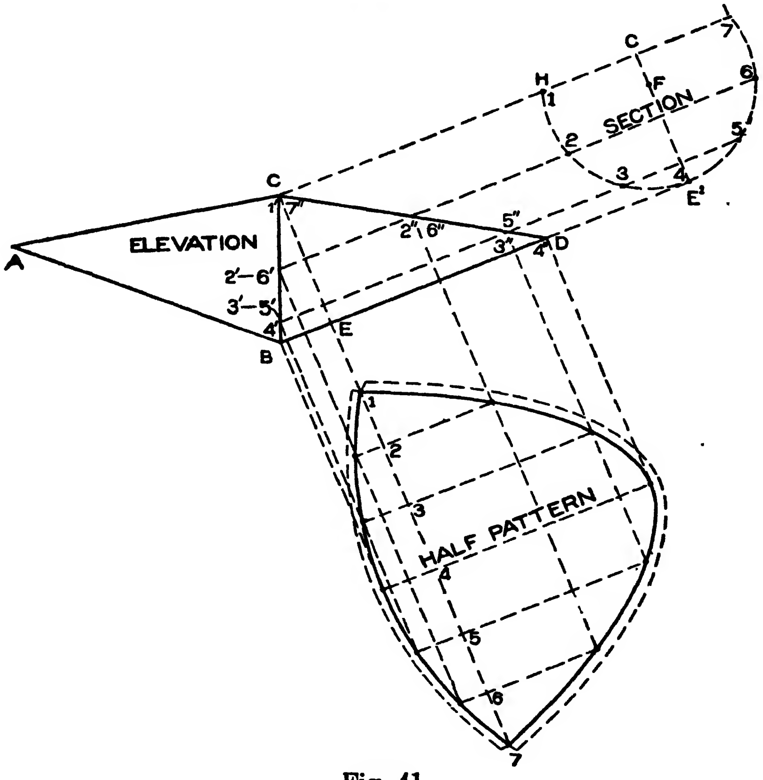


Fig. 41.

points and thus obtain the desired pattern. The dotted outline shows the lap and wire allowance.

In Fig. 42 is shown a perspective view of a **dust pan** with a tapering handle passing through the back of the pan and soldered to the bottom. The first step is to draw the plan and elevation which is shown in Fig. 43. Let ABC be the side view of the pan. Directly below it, in its proper position, draw the bottom DEFG. From the point C in elevation draw a line *d'd* indefinitely. Now bisect the angle EFG. Through *c* and F draw the line *cd*, intersecting the line *dd'* at *d*. From *d* draw a line to G.

In the same manner obtain E*d'*D on the opposite side, which

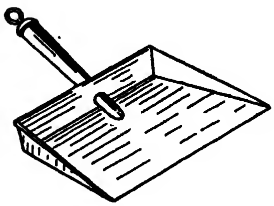


Fig. 42.

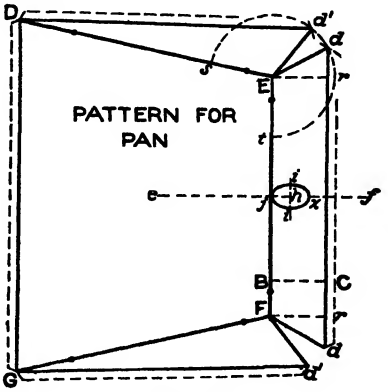


Fig. 44.

will complete the plan view of the pan. Now locate the point *h* in side view, through which the center line of the handle shall pass, and draw the line *lm*. Through *m*, the end of the handle, draw the line *no* at right angles to *lm*, and assume *o* the half width at the top and *j* the point where the contour line of the handle shall meet the back of the pan, and draw a line from *o* through *j*, intersecting the center line *lm* at *l*. Make *mn* equal to *mo* and draw a line from *n* to *l*, intersecting the back of the pan at *x*. Through *h* at right angles to the center line draw *ij''*, giving the diameter of the handle at that point to be used later. This completes the elevation of the handle; the plan view is shown by dotted lines and similar letters, but is not required in developing the pattern.

For the pattern of the pan proceed as is shown in Fig. 44, in which DEFG is a reproduction of similar letters of Fig. 43. Take the distance of BC in side view, Fig. 43, and place it as shown by

BC in Fig. 44 and through C draw a line parallel to EF as shown. At right angles to and from EF draw Er and Fr, then take the distance from r to d in plan in Fig. 43 and place it as shown from r to d on both sides in Fig. 44. Draw the lines dF and dE. Now using E as center, and radius equal to Ed describe the arc st. Then with td as radius and s as center, intersect the arc st at d'. Draw a line from d' to D. In similar manner obtain d'G on the opposite side, which will complete the pattern for the pan. Allow laps for wiring and edging.

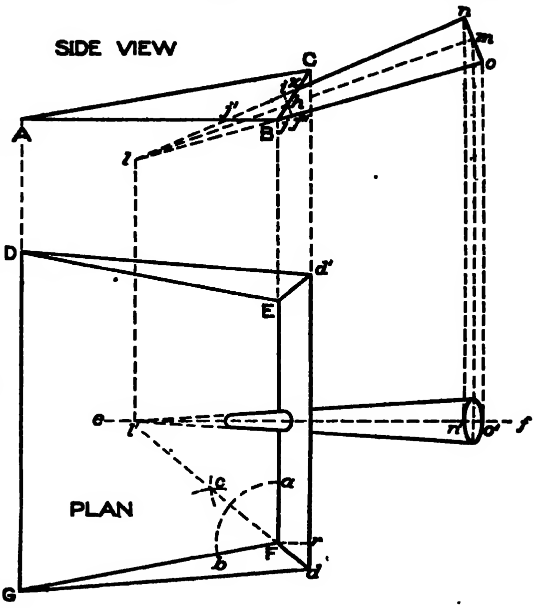


Fig. 43.

The opening in the back of the pan to allow the handle to pass through is obtained by first drawing a center line ef, then take the distances from j to h and h to x in Fig 43, noting that j comes directly on the bend B, and place it in Fig. 44 on the line ef

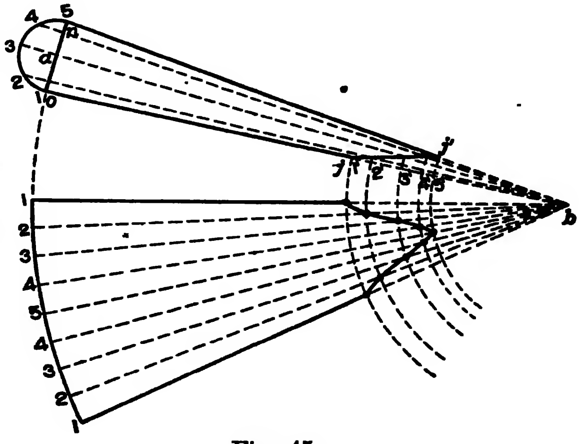


Fig. 45.

from j to h to x, placing j on the bend as shown. Now take the distance from h to i or h to j'' in side view in Fig. 43 and place it in Fig. 44 from h to i on either side; on a line drawn through the points $jixi$ draw an ellipse shown. Fig. 45 shows the method of drawing the pattern for the tapering handle. From the figure we find that we have a frustum of a right cone. To illustrate each step the handle has been slightly enlarged. n, o, j, j' represents n, o, j, j' in Fig. 43. Draw the half section in Fig. 45 as shown. and divide it into equal parts; drop perpendiculars as shown to the line no, and from these points draw lines to the apex b, which is obtained by extending the lines nj' and oj until they

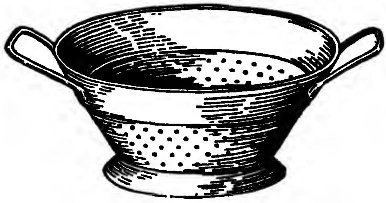


Fig. 46.

meet at b. Where the radial lines intersect the line jj' draw lines at right angles to the center line 3b, intersecting the side of the handle o b at 1′, 2′, 3′, 4′ and 5′. Now with b as a center and bo as a radius, describe the arc 1–1, upon which place twice the number of spaces contained in the half section a. From these points on 1–1 draw radial lines to b and cut them with arcs struck from b as center and radii equal to $b1'$, $b2'$, $b3'$, $b4'$ and $b5'$. Trace a line through points thus obtained to complete the pattern.

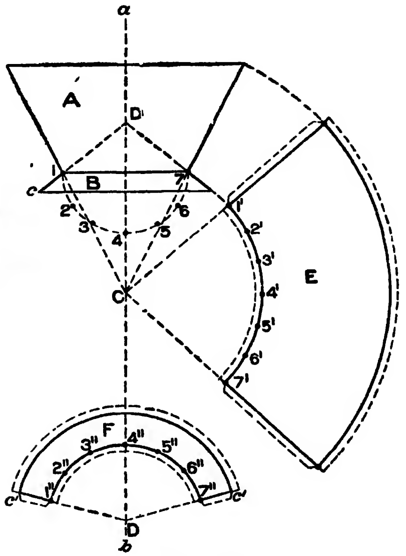


Fig. 47.

Colander. Fig. 46 shows another well-known form of tin ware, known as a colander. The top and bottom are wired and the foot and body seamed together, the handles of tinned malleable iron being riveted to the body. In Fig. 47 is shown how to lay out the patterns. Draw the elevation of the body A and foot B and extend the sides of the body and foot until they meet respec-

tively at C and D on the center line *ab*. Draw the half section on the line 1–7 and divide it into equal parts as shown. For the body, use C as a center and describe the arcs shown, laying off the stretchout on the lower arc, allowing edges in the usual manner. Then E will be the half pattern for the body. In the usual manner obtain the pattern for the foot shown at F, the pattern being struck from D^1 as center, with radii obtained from the elevation D1 and D*c*.

TABLE OF STANDARD OR REGULAR TIN PLATES.

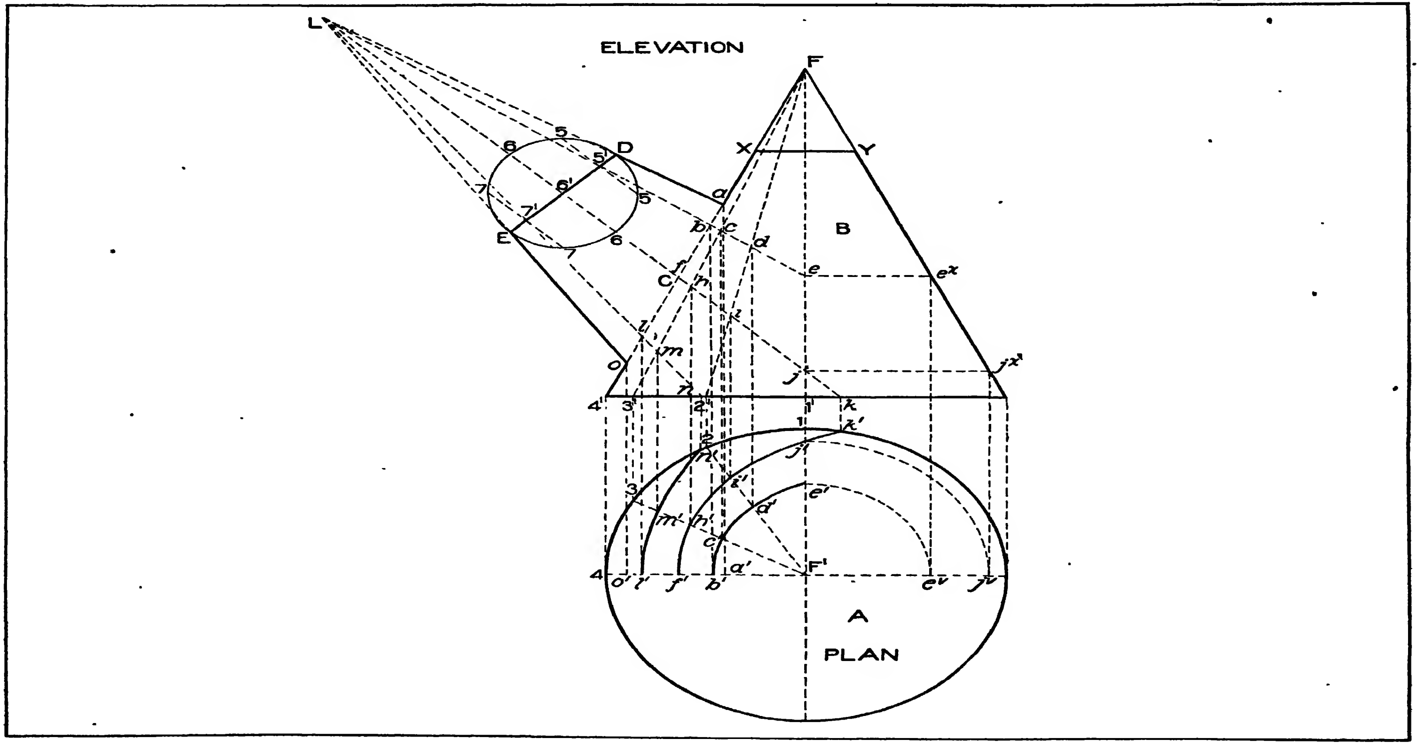
Size and Kind of Plates, Number and Weight of Sheets in a Box, and Wire Guage Thickness, of Every Kind and Size.

Size.	Grade.	Sheets in Box.	Pounds in Box.	Wire Guage.
10 x 10	IC	225	80	29
“	IX	225	100	27
“	IXX	225	115	26
“	IXXX	225	130	25
“	IXXXX	225	145	24 1-2
10 x 14	IC	225	112	29
“	IX	225	140	27
“	IXX	225	161	26
“	IXXX	225	182	25
“	IXXXX	225	203	24 1-2
“	IXXXXX	225	224	24
“	IXXXXXX	225	245	23 1-2
10 x 20	IC	225	160	29
“	IX	225	200	27
11 x 11	IC	225	95	29
“	IX	225	121	27
“	IXX	225	139	26
“	IXXX	225	157	25
“	IXXXX	225	175	24 1-2
11 x 15	SDC	200	168	26
“	SDX	200	189	25
“	SDXX	200	210	24 1 2
11 x 15	SDXXX	200	230	24
12 x 12	IC	225	112	29
“	IX	225	140	27
“	IXX	225	161	20
“	IXXX	225	182	25
“	IXXXX	225	203	24 1-2
“	IXXXXX	225	224	24
“	IXXXXXX	225	245	23 1-2
12 1-2 x 17	DC	100	98	28
“	DX	100	126	26
“	DXX	100	147	24
“	DXXX	100	168	23
“	DXXXX	100	189	22
“	DXXXXX	100	210	21
13 x 13	IC	225	135	29
“	IX	225	169	27
“	IXX	225	194	26
“	IXXX	225	220	25
“	IXXXX	225	245	24 1-2
13 x 17	IXX	225	254	26
13 x 18	IX	225	234	27
“	IXX	225	269	26
14 x 14	IC	225	157	29
“	IX	225	196	27
“	IXX	225	225	26
“	IXXX	225	255	25

TABLE OF STANDARD OR REGULAR TIN PLATES.---Con.

Size.	Grade.	Sheets in Box.	Pounds in Box.	Wire Gauge.
14 x 14	IXXXX	255	284	24 1-2
14 x 17	IX	225	238	27
14 x 20	IC	112	113	29
"	IX	112	143	27
"	IXX	112	162	26
"	IXXX	112	183	25
"	IXXXX	112	202	24 1-2
15 x 15	IX	225	225	27
"	IXX	225	259	26
"	IXXX	225	293	25
"	IXXXX	225	326	24 1-2
15 x 21	IX	112	158	27
"	DXX	100	218	24
"	DXXX	100	249	23
"	DXXXX	100	280	22
15 x 22	IXX	112	190	26
"	SDXX	100	210	24 1-2
"	SDXXX	100	230	24
16 x 16	IC	225	205	29
"	IX	225	256	27
"	IXX	225	294	26
"	IXXX	225	333	25
"	IXXXX	225	371	24 1-2
17 x 17	IC	225	231	29
17 x 17	IX	225	289	27
"	IXX	112	166	26
"	IXXX	112	188	25
"	IXXXX	112	210	24 1-2
17 x 25	DC	100	196	28
"	DX	100	252	26
"	DXX	50	146	24
"	DXXX	50	168	23
"	DXXXX	50	189	22
"	IX	112	213	27
"	IXX	112	244	26
18 x 18	IX	112	162	27
"	IXX	112	186	26
"	IXXX	112	211	25
"	IXXXX	112	235	24 1-2
19 x 19	IC	112	144	29
"	IX	112	180	27
"	IXX	112	207	26
"	IXXX	112	234	25
"	IXXXX	112	262	24 1-2
20 x 20	IC	112	160	29
"	IX	112	200	27
"	IXX	112	230	26
"	IXXX	112	260	25
"	IXXXX	112	290	24 1-2
20 x 28	IC	112	224	29
"	IX	112	280	27
"	IXX	112	322	26

PLATE I



EXAMINATION PLATES.

Drawing Plates I to IV inclusive constitute the examination for this Instruction Paper. The student should draw these plates in ink and send them to the School for correction and criticism. The construction lines and points should be clearly shown. The date, student's name and address, and plate number should be lettered on each plate in Gothic capitals.

In preparing the plates, the student should practice on other paper, and then send finished drawings for examination. The plates of this instruction paper should be laid out in the same manner and of the same size as the plates in Mechanical Drawing Parts I, II and III.

PLATE I.

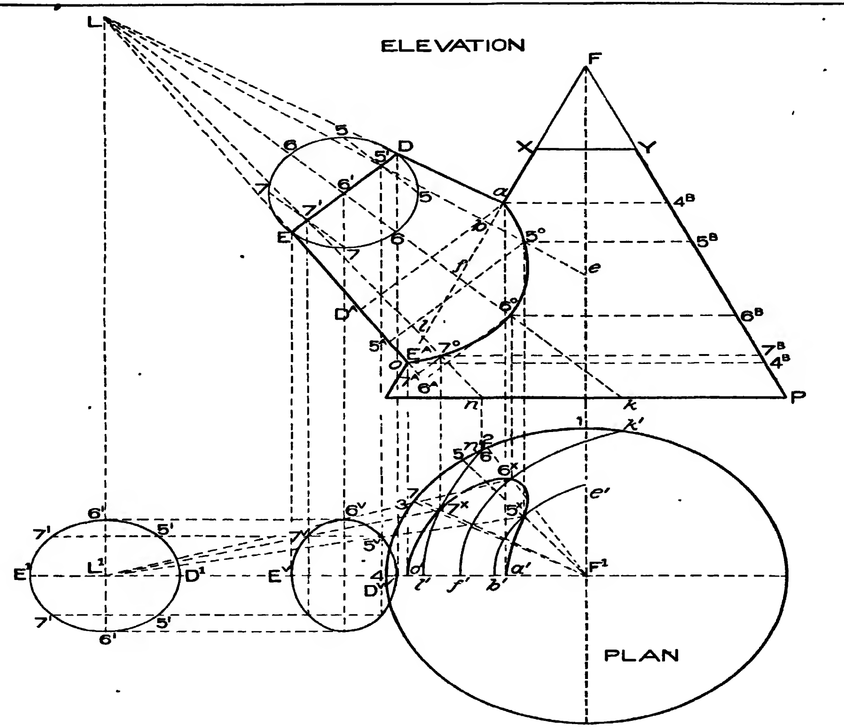
On this plate, the intersection between two right cones is shown. This problem arises in the manufacture of tinware in such instances as the intersections between the spout and body as in a teapot, watering pot, kerosene-oil can, dipper handle and body, and other articles. It is one of the most complicated problems arising in tinsmith work. The problem should be drawn in the center of the sheet making the diameter of the base A 4 inches and the height of the cone B $4\frac{1}{2}$ inches. The distance from X to Y should be 1 inch. From the point F measure down on the side of the cone a distance of $3\frac{1}{8}$ inches and locate the point C, from which draw the axis of the smaller cone at an angle of 45° to the axis of the larger cone. From C measure on CL $1\frac{5}{8}$ inches locating the point 6'; through this point, at right angles to the axis, draw ED equal to $1\frac{1}{2}$ inches. From the point 4' on the base of the cone, measure up on the side of the cone a distance of $\frac{1}{2}$ inch as indicated by *o*, and draw a line from *o* to E, extending it, until it intersects the axis LC at L. From L draw a line through D extending it until it intersects the larger cone at *a*. Then D *a o* E will represent the outline of the frustum of the smaller cone in elevation.

The next step is to obtain the line of intersection between the two cones, but before this can be accomplished, horizontal

sections must be made through various planes of the smaller cone cutting into the larger. As the intersection of each half of the smaller cone with the larger one is symetrical, and as the small cone will not intersect the larger one to a depth greater than the point 1 in plan, divide only one-quarter of the plan into a number of equal spaces as shown by figures 1 to 4; from these points draw radial lines to the center F^1 as shown. Also from points 1, 2, 3 and 4 erect vertical lines intersecting the base of the cone at 1′, 2′, 3′ and 4′ respectively, from which points draw radial lines to the apex F.

Now with 6′ on the line ED as a center describe the circle shown, which represents the true section on ED. Divide each semi-circle into the same number of divisions as shown by the small figures D, 5, 6, 7, and E on either side. From these points at right angles to ED draw lines intersecting the center line ED at 5′. 6′ and 7′. From the apex L draw lines through the intersection 5′, 6′ and 7′, and extend them until they intersect the axis of the large cone at *e* and the base line at *k* and *n*. The student may naturally ask why the radial lines in the small cone are drawn to these points. As it is not known how far the smaller cone will intersect the larger one, we obtain such sections on the planes just drawn, as we think will be required to determine the depth of the intersection. Thus the radial line drawn through 5′ intersects the radial lines through 4′, 3′, 2′ and 1′ in the larger cone, at *b*, *c*, *d* and *e* respectively. The radial line through 6′ intersects radial lines in the larger cone at *f*, *h*, *i*, *j* and the base line at *k*, while the radial line drawn through the point 7′, intersects the radial lines of the larger cone at *l* and *m* and the base at *n*. We know that the line D*a* and E*o* of the smaller cone intersect the larger cone at points *a* and *o* respectively, and determine the true points of intersection; these are shown in plan by *a*′ and *o*′, and therefore no horizontal sections are required on these two planes. For the horizontal section on the plane *b e*, drop vertical lines from the intersections *b*, *c* and *d* on the radial lines, intersecting radial lines having similar numbers in plan as shown by *b*′, *c*′ and *d*′. To obtain the point of intersection in plan of *e* in elevation, draw from the point *e* a horizontal line intersecting the side of the cone at e^x, from which point drop a perpendicular line intersecting the center line in plan at e^v.

PLATE II



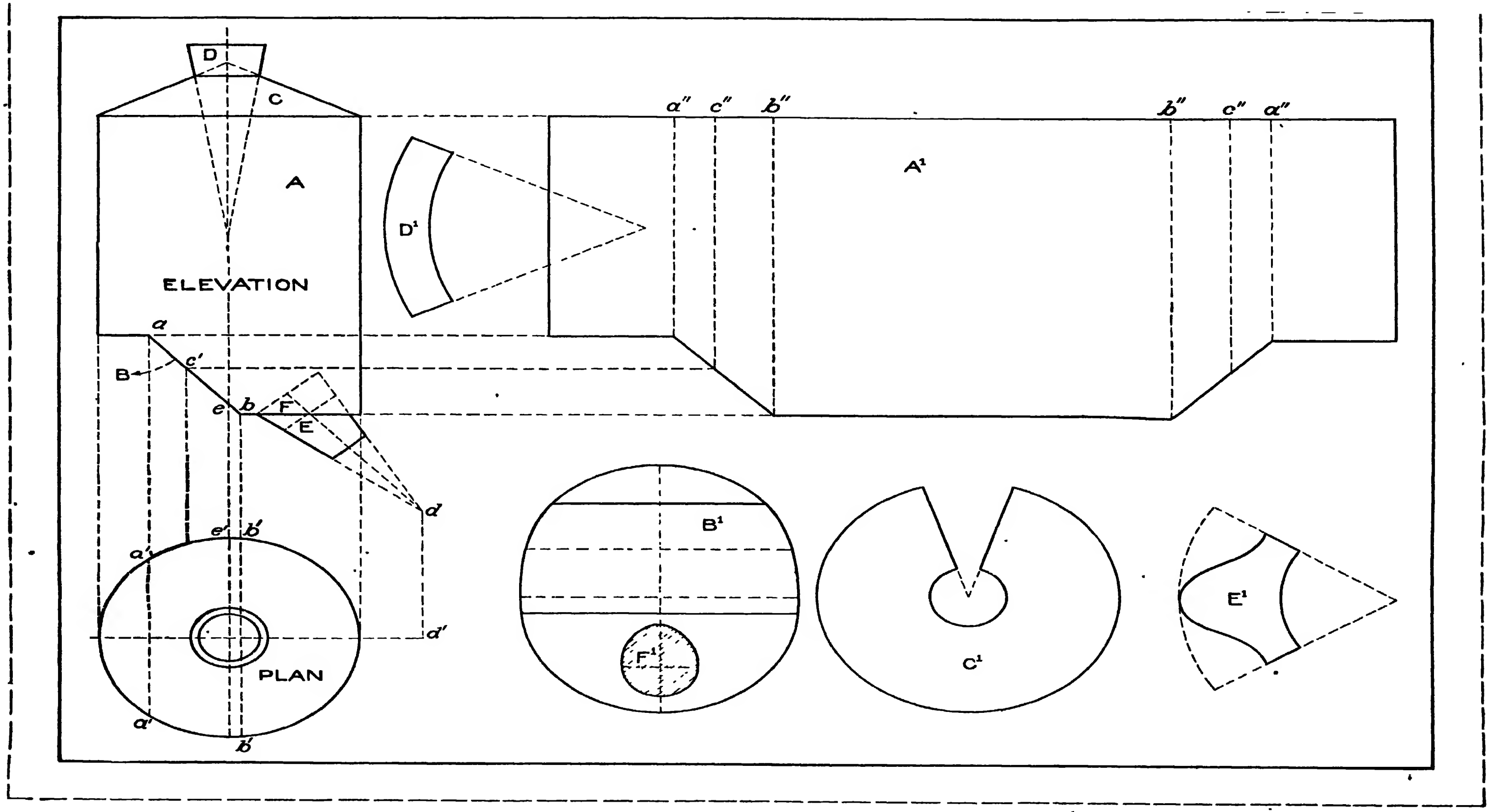
Then using F^1e^v as radius, describe an arc intersecting the radial line 1 at e'. Through the points e', d', c' and b' draw a curved line, which is the half horizontal section of b e in elevation. In the same manner obtain the sections shown in plan by f', h', i', j' and k'; and l', m' and n', which have similar letters and figures in both plan and elevation. The next step is to obtain the intersections where the radial lines of the smaller cone will intersect these sections in plan just obtained. To avoid a confusion of lines which would otherwise occur, a reproduction of the plan and elevation has been transferred to Plate II.

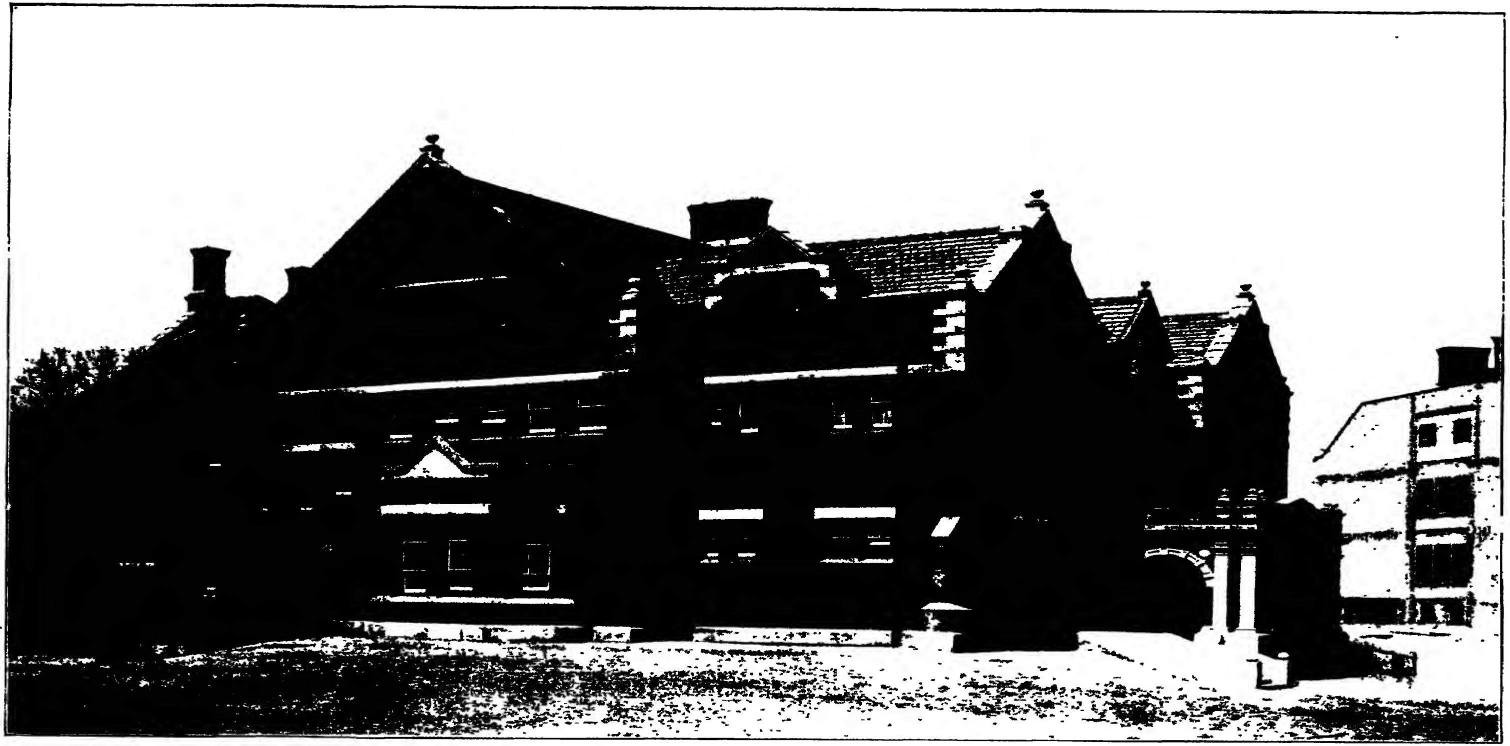
PLATE II.

The figures on this plate are similar to those on Plate I and have similar letters and figures; those letters and figures being omitted which are not necessary. This plate should be studied carefully before proceeding. The reproducing from Plate I can be best done by using a needle point or the small needle which is usually found in the handle of the drawing pen, when unscrewing the pen from the handle, and pricking through Plate I, very small indistinct prick marks. Omit all that is omitted in Plate II, where it will be noticed that the radial line in elevation, of the larger cone, and some of the various small letters in plan are not represented.

To obtain the plan view of the smaller cone, proceed as follows: Extend the line F^1 4 in plan as shown by F^1 E^1. From the apex L of the smaller cone drop a vertical line intersecting F^1 E^1 at L^1, which represents the apex of the smaller cone in plan. With L^1 as center and radius equal to the radius 6′ D describe the circle E^1 D^1 and divide the circumference into the same number of spaces as ED, being careful to number the spaces as is there shown. The reason for doing this may be better understood from what follows: Assume that ED is a pivot on which the circle turns, so that it lies on a plane ED, then by looking down from the top, the points 6 and 6 appear as shown by 6′ and 6′ in plan.

A better illustration is obtained by cutting a card-board disc and after spacing it and numbering the points hold it in various positions until all the points become clear. Now from the intersections on ED in elevation, drop lines, intersecting horizontal lines drawn from similar numbered points in the profile E^1 D^1,


D
C
A
ELEVATION
a
B
c'
e
b
F
E
d'
e'
b'
a'
PLAN
a'
b'
d'
D¹
a"
c"
b"
A¹
b"
c"
a"
B¹
F¹
C¹
E¹



DOUBLE-COTTAGE DORMITORIES, PARENTAL SCHOOL, MAYFAIR, ILL.

W. B. Mundie, Architect, Chicago, Ill.

Built in 1904   Cost, $40,000.   Walls of Paving Brick, with Bedford Stone Trimmings   Roofs of Interlocking Red Shingle Tile.

SUPERINTENDENT'S COTTAGE, PARENTAL SCHOOL, MAYFAIR, ILL.

W. B. Mundie, Architect, Chicago, Ill.

Built in 1904. Cost, $12,000. First Story, Paving Brick, with Stone Trimmings; Second Story, Half-Timber Work; Roof, Interlocking Red Shingle Tile.

cone to admit the intersection of the smaller. We must now again refer to Plate II. From the intersections *a*, 5°, 6°, 7°, and *o* in elevation draw lines at right angles to the line of the axis, intersecting the side of the cone at 4^B, 5^B, 6^B, 7^B and 4^B.

Also in addition to the spaces 1, 2, 3 and 4 in the plan view, it will be necessary to obtain the points of intersection on the base line in plan, where the radial lines would intersect drawn from the apex F^1 through the points of intersections between the two cones. This is accomplished by drawing lines from F^1 through 5^x, 6^x and 7^x until they intersect the base line in plan at 5, 6 and 7. All these points form the basis with which to develop the pattern shown in Fig. 2 of Plate III, in which draw the vertical line F 4, and with F as a center and radii equal to FY, and F P in Plate II draw the arcs YY and PP in Fig. 2 of Plate III as shown. Now starting from the point 4 on the arc PP on either side, lay off the stretchout of 1, 6, 5, 7 and 4 in plan in Plate II as shown by similar numbers in Fig. 2 of Plate III. From the points 6, 5, 7 and 4 on either side draw radial lines to the apex F, which will be used to obtain the pattern for the opening. Now with F as center and radii equal to F 4^B, F 5^B, F 6^B, F 7^B and F 4^B in Plate II, describe arcs intersecting radial lines having similar numbers in Fig. 2 of Plate III as shown by intersections having similar numbers. A line traced through these points will be the required opening to be cut out of the pattern of the larger cone, one-half of which is shown by drawing radial lines from the points 1 and 1 to the apex F.

PLATE IV.

In drawing this plate, the same size paper and border lines should be used as for the preceding plates. The subject for this plate is an oil tank resting on inclined wooden racks. The problem involves patterns in parallel and radial-line developments. The drawing can be made to any convenient scale until the problems are understood and should be proven by paste-board models. It should be drawn to a convenient scale, placing the pattern to fill the sheet and make a neat appearance. The section, stretchout lines, construction lines, and developments should be numbered or lettered, so as to prove the thorough understanding of the problem, and then sent to the School for correction. The var-

ious parts in the elevation and patterns have similar letters. A represents the tank body, the pattern being shown by A^1. B shows the bottom, the pattern being shown by B^1. The cone top C and inlet D are shown developed by C^1 and D^1 respectively, while the outlet E and opening F in elevation are shown developed by E^1, and F^1 in the bottom B^1.

ELBOW PATTERNS *

In all elbow work the difficulty lies in obtaining the correct rise of the miter line. By the use of a protractor this is overcome and thus the necessity of drawing a complete quadrant is avoided. Following the rule given in the illustration the rise can be easily found, when the throat and diameter of the pipe is known.

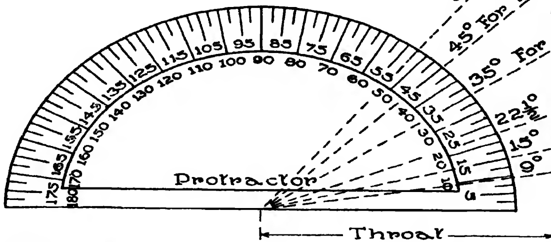
In the upper table are shown various pieced elbows, having different degrees when finished, and the various miter lines. There are six miter patterns shown, the first for a 6-pieced elbow having 90° when completed; the second for a 4-pieced 90° elbow; the third for a 3-pieced 90° elbow; the fourth for a 2-pieced 70° elbow; the fifth for a 2-pieced 90° elbow, and the sixth for a 2-pieced 105° elbow.

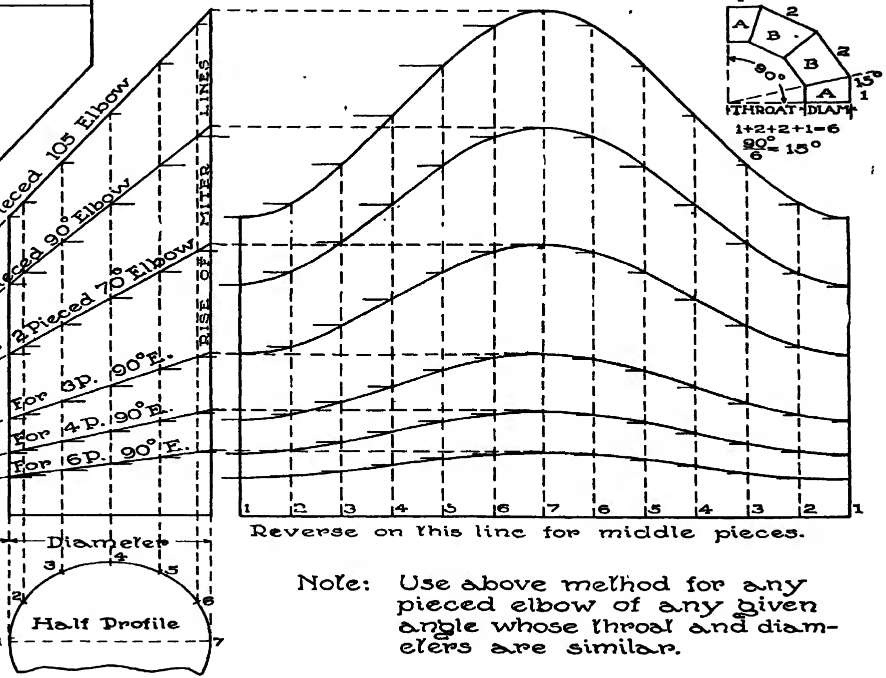
No matter what size of throat the elbow may have, or what diameter or number of pieces, always follow the rule given in the illustration and obtain the miter line; then place the half profile in its proper position and place the full girth of the pipe on the line shown in the pattern by similar numbers. By reversing the cut opposite the line 1–7–1 the pattern for the middle pieces is obtained, after which one cut can be placed into the other as shown on Page 48 Sheet Metal Work, Part I.

* The illustration referred to will be found on the back of this page.

PATTERNS FOR VARIOUS PIECED ELBOWS OF SIMILAR THROAT AND DIAMETER.

NO. OF PIECES	DIVIDE BY	DEGREE OF ELBOW	RISE OF MITER LINE
2	2	105	$52\frac{1}{2}°$
2	2	90	45°
2	2	70	35°
3	4	90	$22\frac{1}{2}°$
4	6	90	15°
6	10	90	9°





Rule: In all elbow work, no matter what degree the elbow may have, the end-piece "A" counts one, and each middle piece "B" counts two; thus in a four pieced elbow divide by six.

Note: Use above method for any pieced elbow of any given angle whose throat and diameters are similar.

FOR EXPLANATION OF THIS PROBLEM SEE BACK OF PAGE

SHEET-METAL WORK.

PART I.

The sheet-metal worker of today who wishes to succeed must know far more than was necessary years ago. There are many good, practical sheet-metal workers in the trade who are handicapped because they are unable to lay out the patterns that arise in their daily work. Notwithstanding the introduction of labor-saving machinery, the demand for good workmen has increased. While most sheet-metal workers acquire practical knowledge in the shop, they lack the technical education necessary to enable them to become proficient as pattern cutters and draftsmen. In this course, special attention is given to the fundamental principles that underlie the art and science of pattern drafting.

Practical workshop problems will be presented, such as arise in everyday practice, thus giving the student the practical experience that usually comes only after long association with the trade.

CONSTRUCTION.

In constructing the various articles made from sheet metal, various gauges or thicknesses of metal are used. For all gauges from No. 20 to No. 30 inclusive, we assume in the development of the pattern, that we are dealing with no thickness, and we make no allowance for bending or rolling in the machine. But where the metal is of heavier gauge than No. 20, allowance must be made for shrinkage of the metal in the bending and rolling operations, which will be explained in connection with development in heavy sheet-metal work. What has been said about wiring, seaming, and transferring patterns in the Tinsmith's Course is applicable to this course also. It is sometimes the case that the capacity of a vessel or article must be determined, when the rules given in Mensuration should be followed. When figuring on sheet-metal work, the specifications sometimes call for various metals, such as galvanized sheet iron or steel, planished iron, heavy boiler plate,

band iron, square or round rods for bracing, etc., zinc, copper, or brass; and the weight of the metal must often be calculated together with that of stiffening rods, braces, etc. On this account it is necessary to have tables which can be consulted for the various weights.

TABLES.

There is a wide difference between gauges in use, which is very annoying to those who use sheet metal rolled by different firms according to the various gauges adopted. It would be well to do away with gauge numbers, and use the micrometer caliper shown in Fig. 1, which determines the thickness of the metal by the decimal or fractional parts of an inch.

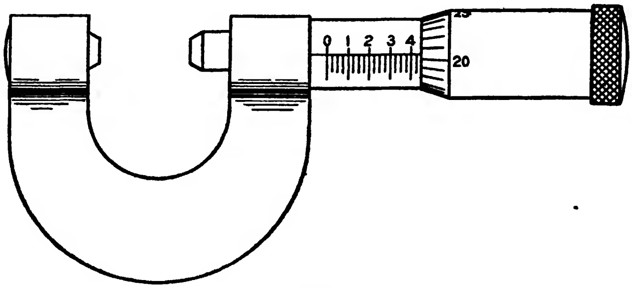


Fig. 1.

This is the most satisfactory method for the average mechanic who works sheet metal manufactured by firms using different gauges. The tables on pages 61 to 74 can be consulted when occasion arises.

SHOP TOOLS.

In allowing edges for seaming and wiring, we must bear in mind that when a seam is to be grooved by hand or machine the allowance to be made to the pattern should conform to the rolls in the machine or the hand tools in use. The edges of the pattern are usually bent on the sheet-iron folder, or brake, while the seam can be seamed or grooved with the hand groover or giant grooving machine. Where round pipe work is done in lengths up to 3 feet, the slip roll former is used, while square or rectangular pipes are bent up on the brake in 8-foot lengths. Where pipes, elbows,

stove bodies, furnace shells, metal drums, etc., are made, the sheets are cut square on the large squaring shears, rolled, grooved, and stiffened, by beading both ends in the beading machine, using ogee rolls. There is also a special machine for seaming the cross seams in furnace pipes, also a set of machines for the manufacture of elbows used in sheet-metal work. As before mentioned, if these machines are at hand, it will be well to make slight modifications in the patterns so that both the machines and patterns may work to advantage.

PATTERNS OBTAINED BY VARIOUS METHODS.

In this course will be explained the four methods used in developing patterns for sheet-metal work, namely, parallel line, radial line, triangulation, and approximate developments. What was said on parallel and radial line developments in the Tinsmith's Course is applicable to this course also.

INTERSECTIONS AND DEVELOPMENTS.

The following problems on parallel line developments have been selected because they have a particular bearing on pipe work arising in the sheet-metal trade. All of the problems that will follow should be carefully studied, drawn on cheap paper, and proven by cardboard models. These models will at once show any error in the patterns which might otherwise be overlooked. As only the Examination Plates are to be sent to the School, the student should draw all the other plates given in this course.

The first problem to be drawn is shown in Fig. 2, being the intersection between a cylinder and octagonal prism. In drawing these problems for practice, make the cylinder and octagonal prism both 2 inches in diameter. The height of the cylinder from B to E should be $4\frac{1}{2}$ inches; and the length of the prism from G to H, 3 inches. Let A represent the plan of the cylinder, shown in elevation by B C D E; and F, the section of the prism, shown in plan by G H I J. Number the corners of the section F as shown, from 1 to 4 on both sides; and from these points draw horizontal lines intersecting the plan of the cylinder at $2'3'$ and $1'4'$ on both sides as shown. Establish a convenient intermediate point of intersection between the corners of the prism, as *a* and *a* in A, from

which draw horizontal lines intersecting the section F at a', a', a', and a'. Take a tracing of the section F with its various intersections, and place it in its proper position as shown by F^1, in the

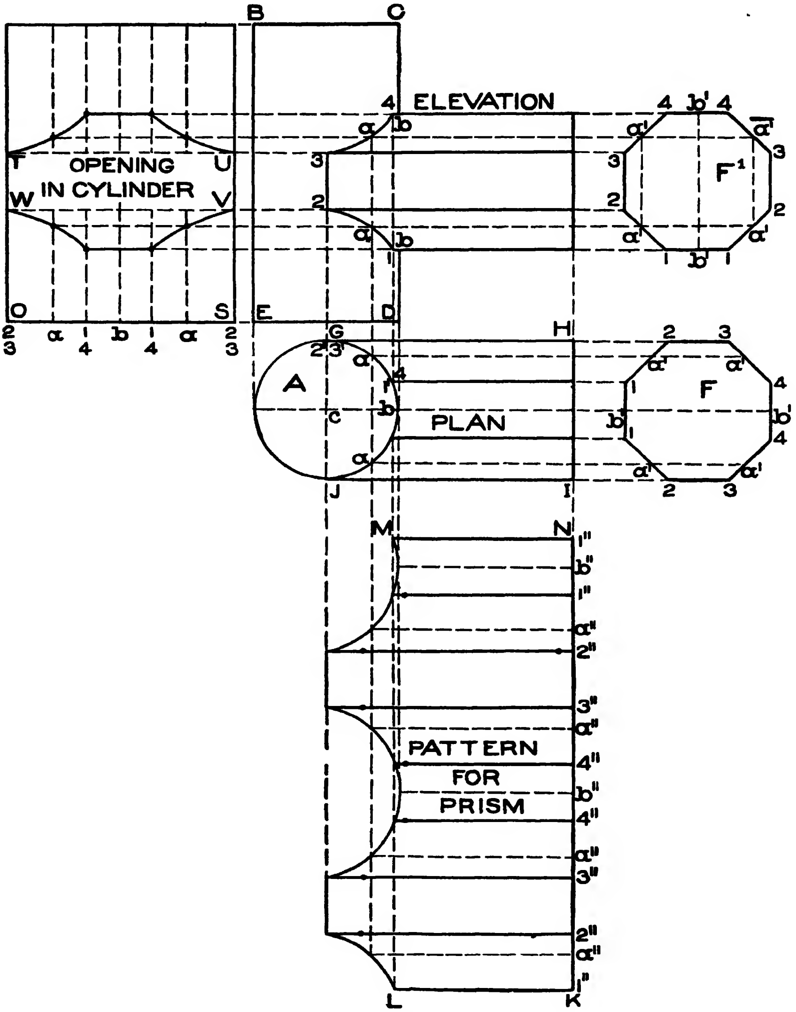


Fig. 2.

center of the cylinder B C D E, allowing the section to make a quarter turn, and bringing the points b' b' at the top and bottom on a vertical line, while in the section F, b' b' are on a horizontal

line. From the various intersections in F^1, draw horizontal lines intersecting vertical lines drawn from similarly numbered intersections in the plan A, as shown in elevation. A line drawn through these points will represent the joint between the cylinder and prism.

For the development for the prism, extend the line H I in plan as N K, upon which place the stretchout of all the points contained in the section F, as shown by similar figures and letters on N K. Through these points, at right angles to N K, draw lines which intersect with lines drawn from similarly numbered points and letters in plan, at right angles to J I. Trace a line through points thus obtained, and K L M N will be the desired pattern. To obtain the development for the opening in the cylinder, extend the line D E in elevation as S O, upon which place the stretchout of all the points contained in the half-circle A, as shown by similar numbers and letters on S O. At right angles to S O and through these points, draw lines intersecting horizontal lines drawn from intersections having similar numbers and letters in elevation, thus obtaining the intersections shown by T U V W, which will be the shape of the opening to be cut into one-half of the cylinder.

In Fig. 3 is shown the intersection between a hexagonal and quadrangular prism, the hexagonal prism being placed in elevation at an angle of 45° to the base line. When drawing this problem for practice, make the height of the quadrangular prism $4\frac{1}{2}$ inches, and each of its sides 2 inches. Place the hexagonal prism at an angle of 45° to the base line, placing it in the center of the quadrangular prism in elevation as shown; and inscribe the hexagonal section in a circle whose diameter is $2\frac{1}{2}$ inches. Let A represent the plan of the quadrangular prism placed diagonally as shown, above which draw the elevation B C D E. In its proper position and proper angle, draw the outline of the hexagonal prism as shown by 1^v $1''$ $4''$ 4^v; and on $1''$ $4''$ draw the half section as shown by F, numbering the corners $1''$ $2''$ $3''$ and $4''$. From the corner $1'$ in the plan A, draw the center line $1'$ 4. Take a tracing of the half section F, and place it as shown by F^1, placing the points $1''$ $4''$ in F on the center line in F^1 as shown. From the corners 1, 2, 3, and 4, draw lines parallel to the center line, intersecting the two sides of A (b $1'$ and $1'$ a) at $2'$ $3'$ and $1'$ $4'$, as shown. From

these intersections draw vertical lines, which intersect by lines drawn parallel to $4''$ 4^v from corners having similar numbers in F, thus obtaining the points of intersection 1^v 2^v 3^v and 4^v. Dropping vertical lines from the intersections on the plane $1''$ $4''$ in elevation, and intersecting similarly numbered lines in plan, will give the horizontal section of $1''$ $4''$, as shown by $1°$ $2°$ $3°$ and $4°$.

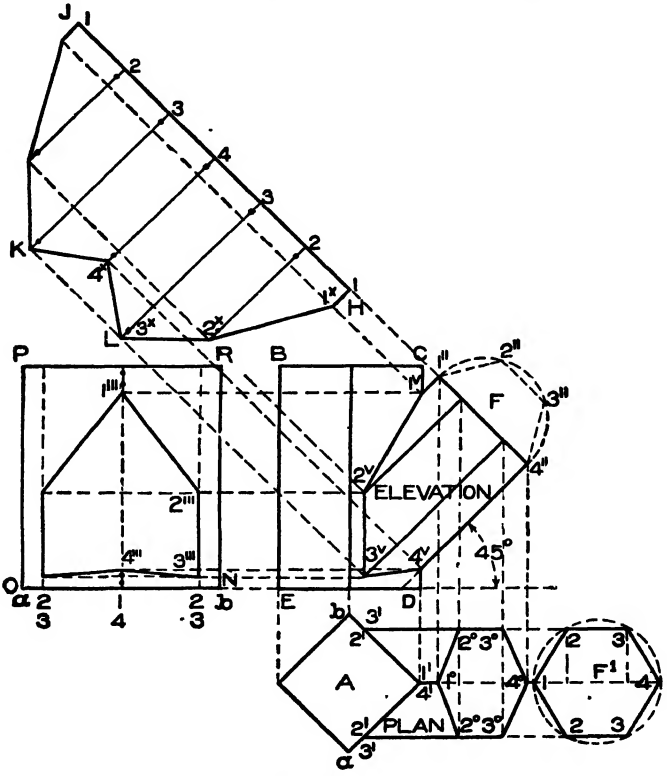


Fig. 3.

For the development of the hexagonal prism, extend the line $4''$ $1''$ as shown by H J, upon which place the stretchout of twice the number of spaces contained in the half section F, as shown by similar figures on the stretchout line H J. From these points, at right angles to H J, draw lines as shown, which intersect by lines drawn at right angles to the line of the prism from intersections 1^v to 4^v, thus obtaining the points of intersection 1^x to 4^x. Lines

traced from point to point as shown by J K L H, will be the required development. The shape of the opening to be cut into the quadrangular prism, is obtained by extending the line D E in elevation as N O, upon which place the stretchout of one-half the section A, with the various points of intersection, as shown by similar figures on O N. At right angles to O N erect lines from these points, which intersect by lines drawn from similarly numbered intersections in elevation at right angles to the quadrangular prism, thus obtaining the points of intersection 1‴ to 4‴ on both sides. Then N O P R will be the half development.

Fig. 4 shows the intersection between two cylinders of equal diameters at right angles. Make the height of the vertical cylinder 3 inches, that of the horizontal cylinder 1¼ inches, and the diameters of both 2 inches. Let A represent the plan of the vertical cylinder, and B its elevation. Draw the plan of the horizontal cylinder C, shown in elevation by D placed in the center of the vertical cylinder. Draw the half section E in plan and divide it into equal parts, as shown from 1 to 3 to 1. In a similar manner draw the half section E^1 in elevation, which also divide into the same number of spaces as E, reversing the numbers as shown.

The following suggestions are given to avoid confusion in numbering the points or corners of irregular or round sections in plan and elevation. If the half section E were bent on the line 1–1 and turned upward toward the reader, and we should view this section from the front, the point 3 would be at the top, or, if bent downward, would be at the bottom; therefore the points 3 and 3 in elevation are placed at top and bottom. Now if the section E^1 in elevation were bent on the line 3-3 either toward or away from the reader, the point 1 when looking down would show on both sides as shown in plan, which proves both operations. No matter whether the form is simple, as here shown, or complicated as that which will follow, the student should use his imaginative power. Study the problem well; close your eyes and imagine you see the finished article before you, or, failing in this, make a rough model in the shop or a cardboard model at home, which will be of service. Now from the intersections in E, draw horizontal lines intersecting the circle A at 1′, 2′ and 3′ on both sides. From these points erect perpendicular lines and intersect them with horizontal lines drawn

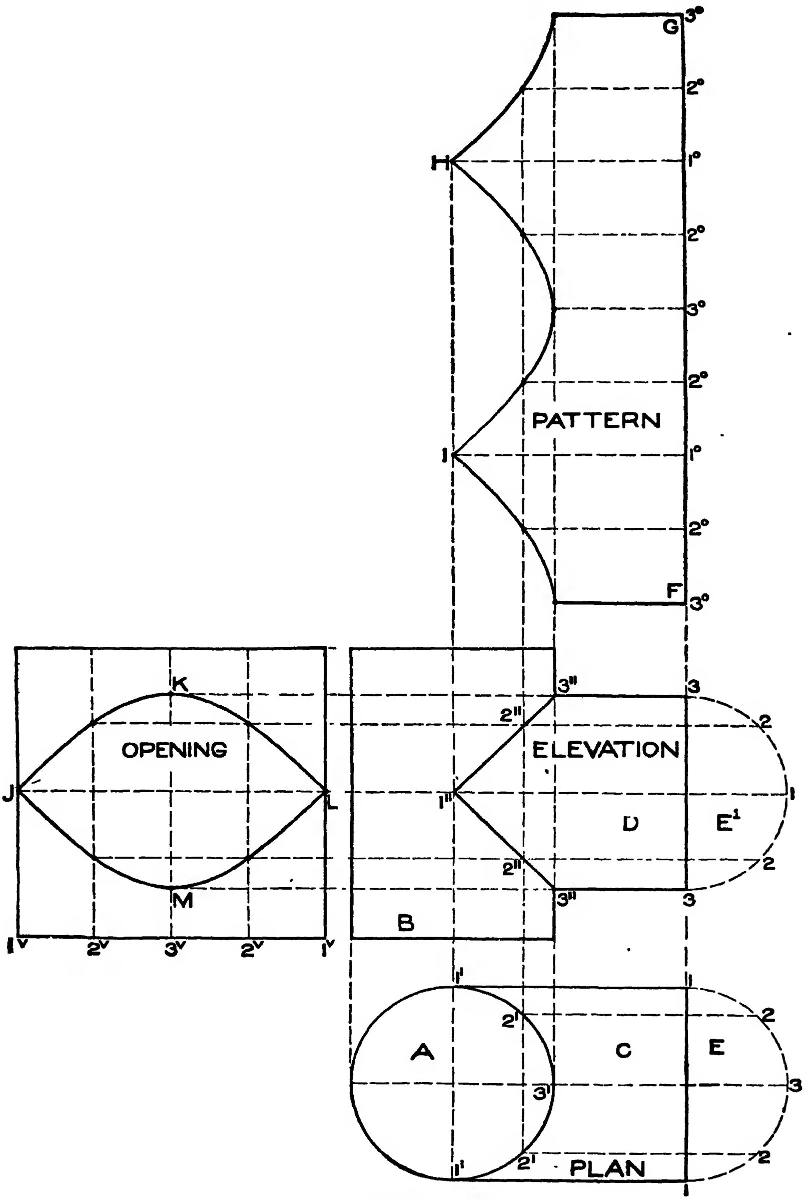

G
3^o
2^o
H
1^o
2^o
3^o
2^o
PATTERN
I
1^o
2^o
F
3^o
K
OPENING
J
L
M
1^v
2^v
3^v
2^v
1^v
$3''$
3
$2''$
2
ELEVATION
$1''$
1
D
E^1
$2''$
2
$3''$
3
B
$1'$
1
$2'$
2
A
C
E
$3'$
3
$1'$
$2'$
PLAN
2

Fig. 4.

from similarly numbered intersections in E^1. Lines traced through these points $3'' \, 2'' \, 1''$ and $1'' \, 2'' \, 3''$ will be straight because both branches are of equal diameters.

For the development of the cylinder D in elevation, extend the line 3-3 as shown by F G, upon which place the stretchout of twice the number of spaces contained in E^1, as shown by similar numbers 3° to 1° to 3° to 1° to 3° on the stretchout line F G. From these points, at right angles to G F, draw lines, and intersect them by lines drawn parallel to the cylinder B from similar numbers in the joint line. Trace a line through these points in the development, when F G H I will be the desired shape.

For the opening to be cut into the cylinder B to receive the cylinder D, extend the base of the cylinder B as shown by $1^v \, 1^v$, upon which place the stretchout of the half circle A in plan, as shown by similar figures on the stretchout line $1^v \, 1^v$. From these points erect perpendiculars, which intersect by lines drawn from similarly numbered intersections in elevation at right angles to the line of the cylinder B. Trace a line through the intersections thus obtained; J K L M will be the shape of the opening.

Fig. 5 shows the intersection of two cylinders of unequal diameters at an angle of 45°. Make the diameters of the large and small cylinders 2 inches and $1\frac{1}{4}$ inches respectively; the height of the large cylinder 3 inches; and the length of the small cylinder measured from its shortest side in elevation, 1 inch, placed at an angle of 45° in the center of the cylinder B. A represents the plan of the large cylinder struck from the center a and shown in elevation by B. Draw the outline of the small cylinder C at its proper angle, and place the half section D in its position as shown; divide it into a number of equal spaces, as shown from points 1 to 5. Through the center a in plan. draw the horizontal line a 5; and with b as a center describe a duplicate of the half section D with the various points of intersection, as shown by D^1, placing the points 1 and 5 on the horizontal line a 5. From the intersections in D^1 draw horizontal lines intersecting the large circle A at $3'$ to $3'$ as shown, from which points erect perpendicular lines; intersect them by lines drawn parallel to the lines of the smaller pipe from similarly numbered intersections in D. A line

traced through the points thus obtained will represent the intersection or miter joint between the two pipes.

These same principles are applicable no matter what diameters the pipes have, or at what angle they are joined, or whether the

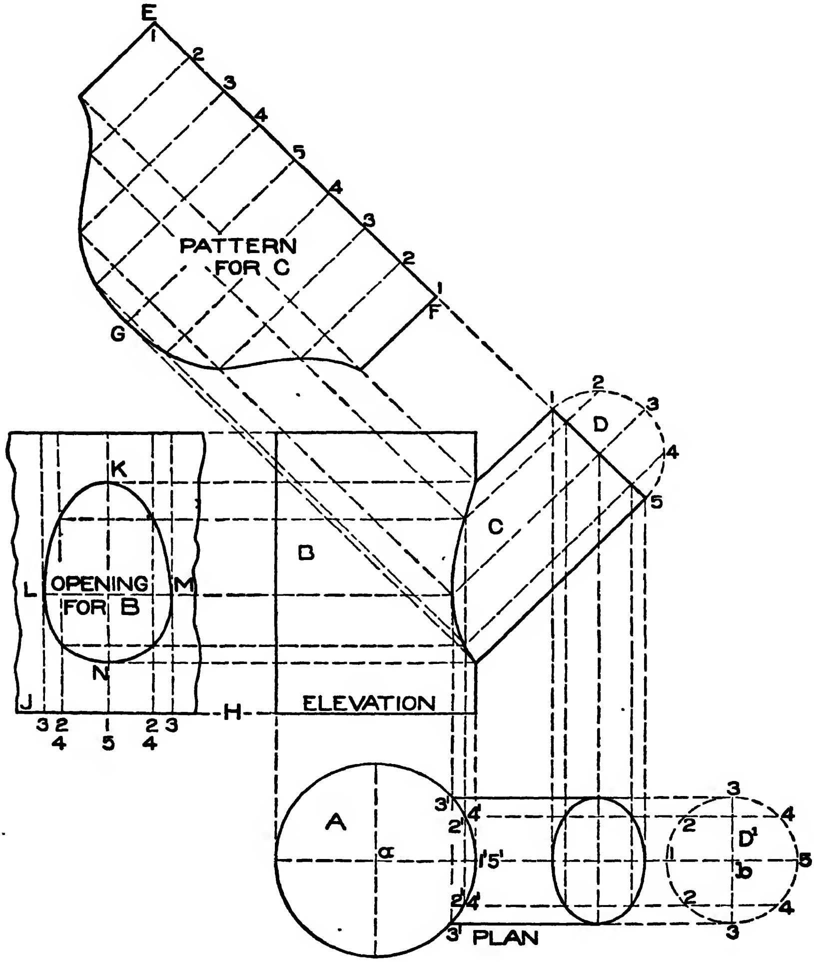


Fig. 5.

pipe is placed as shown in plan or at one side of the center line.

For the development of the small cylinder extend the line 5 – 1 in elevation as shown by F E, upon which place the stretchout

of the circle D^1 in plan, or twice the amount of D in elevation, as shown by similar figures on the stretchout line F E. At right angles to F E and through these small figures, draw lines which intersect with lines drawn at right angles to the lines of the small cylinder from similarly numbered intersections in the miter line in elevation. Trace a line through the points thus obtained; E F G will be the development for the cylinder C.

To obtain the opening in the large cylinder extend the lines of the large cylinder in elevation as shown at the base by H J, upon which place the stretchout of the intersections contained in the circle A, being careful to transfer each space separately (as they are unequal) to the stretchout line H J. Through these points and at right angles to H J erect lines which intersect with horizontal lines drawn from similar points in the miter line in elevation A line traced through the points thus obtained, as shown by K L M N, will be the desired development.

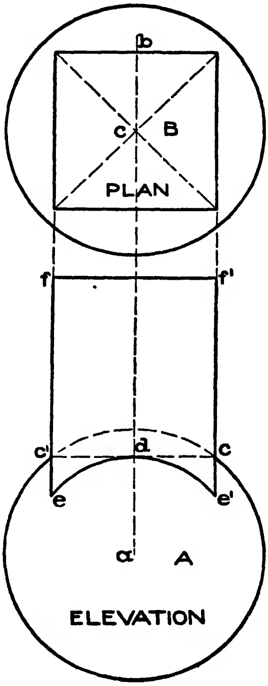


Fig. 6.

Fig. 6 shows the intersection between a quadrangular prism and sphere, the center of the prism to come directly over the center of the sphere. Make the diameter of the sphere $2\frac{1}{2}$ inches, the sides of the prism $1\frac{1}{2}$ inches, and the height from f to c' $2\frac{5}{8}$ inches. Draw the elevation of the sphere A which is struck from the center a, from which erect the perpendicular $a\ b$. With any point, as c, as a center and using the same radius as that used for A, describe the plan B. Through c draw the two diagonals at an angle of 45°, and draw the plan of the prism according to the measurements given. Now draw the elevation of the prism $f\ c'$ and $f'\ c$, the sides of the prism intersecting the sphere at c and c'. From either of these points draw a horizontal line intersecting the center line $a\ b$ at d. Then using a as a center and $a\ d$ as the radius, describe the arc $e\ e'$ intersecting the sides of the prism extended at e and e'; $f\ e\ e'\ f'$

will be the development for one of the sides of the prism. In practice the four sides are joined in one.

Fig. 7 shows the intersection of a quadrangular prism and sphere when the center of the prism is placed to one side of the center of the sphere. Make the diameter of the sphere the same as in the preceding figure; through x in the plan draw the 45° diagonal, and make the distance from x to A $\frac{1}{2}$ inch, the sides of the prism 1 inch, and the height from E to c in elevation $1\frac{1}{2}$ inches.

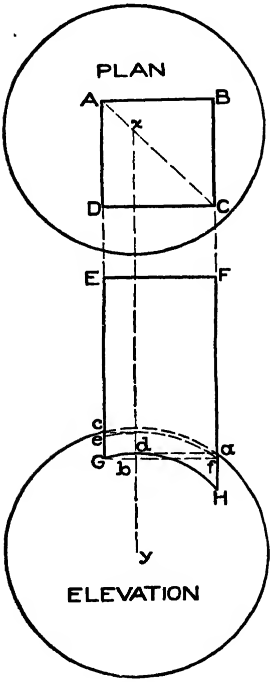
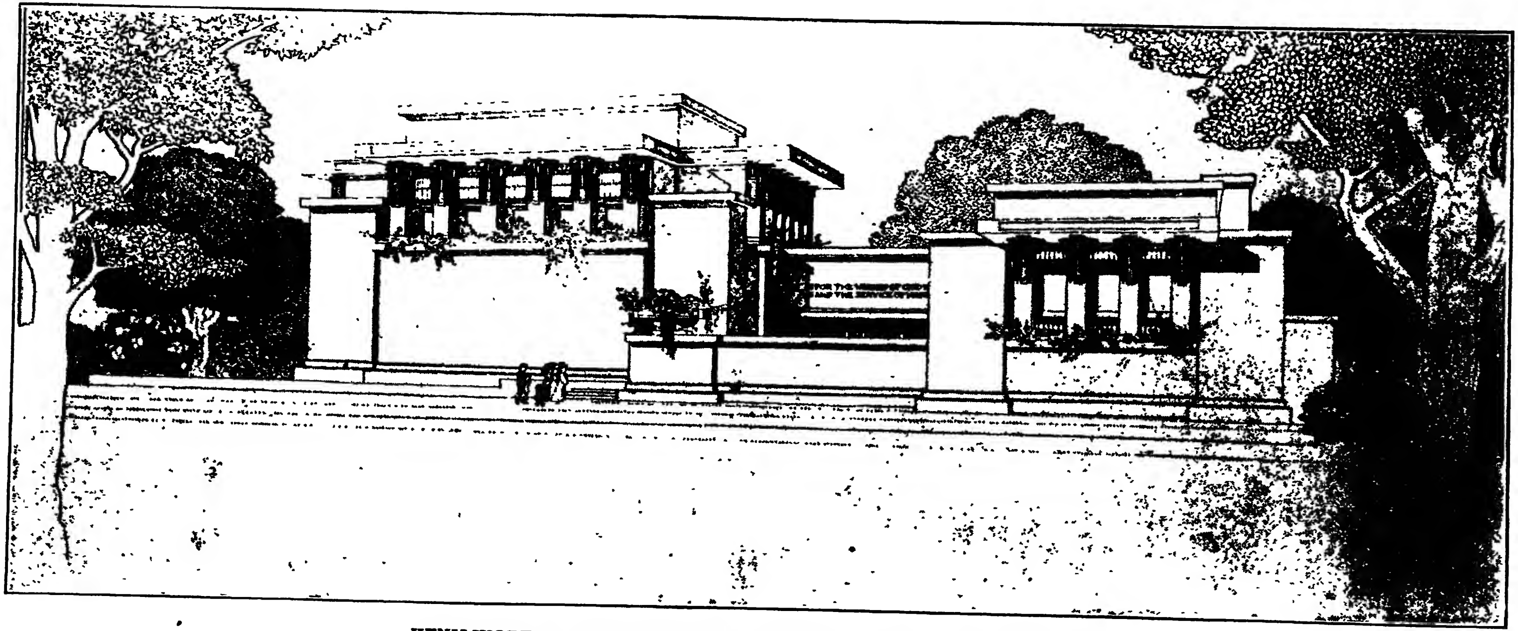


Fig. 7.

Having drawn the elevation and plan of the sphere, construct the plan of the prism as shown by A B C D. Parallel to the center line x y project the prism in elevation intersecting the sphere at a and c. Now since the center of the sphere is on one of the diagonals of the prism in plan, either two of the sides meeting at one end of that diagonal, as B C and C D, will be alike, and both will be different from the other two sides A B and A D, meeting at the opposite end of the diagonal. Therefore the line F a in elevation will be used in obtaining the development of D C in plan, while the line E c will be used in obtaining the development for the two sides D A and A B in plan.

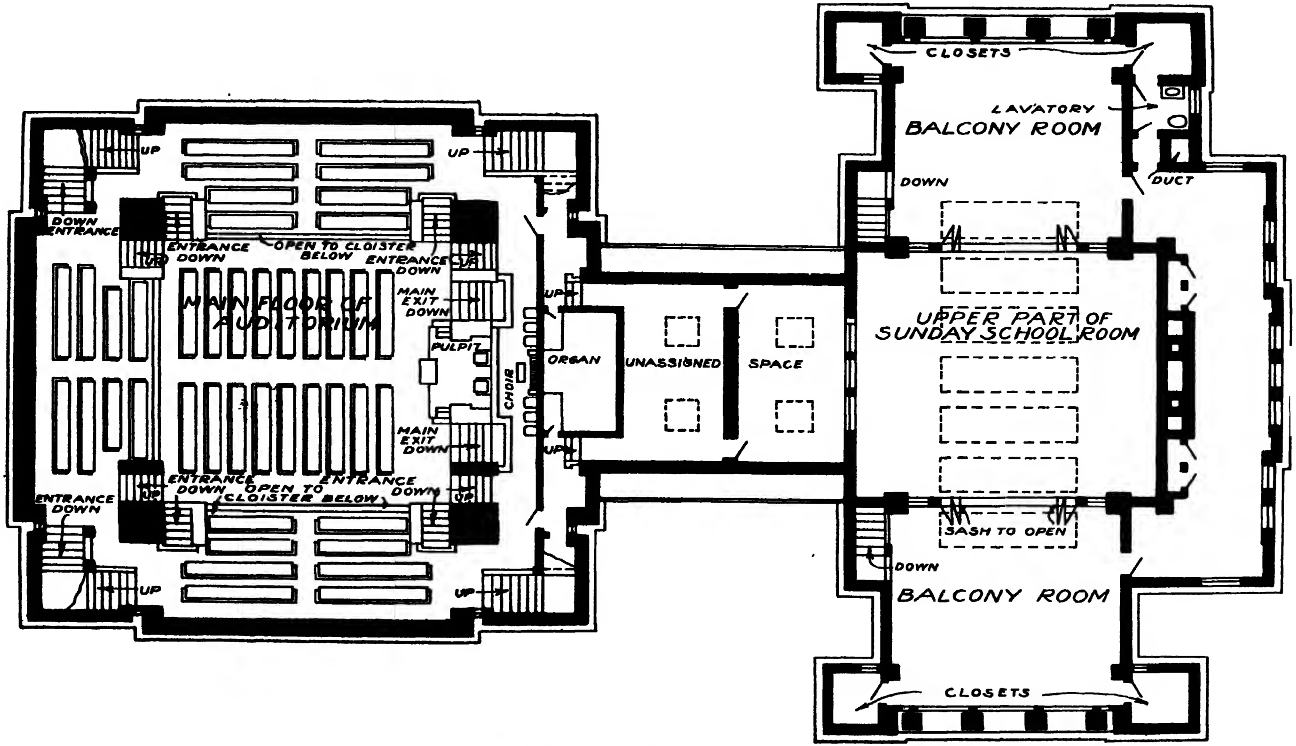
Now from a draw a horizontal line intersecting the center line x y at b; and using y as a center and y b as the radius, describe the arc G H intersecting the sides of the prism extended to G and H. Then E F G H is the development for each side of the prism shown in plan by D C and C B. In a similar manner, from the intersection c in elevation draw a horizontal line intersecting the center line x y at d. Then using y as center and y d as radius, describe an arc intersecting the sides of the prism at e and f. E F f e will show the development for either side of the prism shown in plan by D A and A B. By connecting the points G and f it will be found that the line is a true horizontal line, which proves



KENILWORTH AVENUE FAÇADE OF UNITY CHURCH, OAK PARK, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.

Built in 1907. Entirely of Concrete. Cost, $40.000. Only Flat Roofs are Used in the Structure—an Unusual Treatment for a Church. For Plan, See Opposite Page.



PLAN OF THE TEMPLE FLOOR, UNITY CHURCH, OAK PARK, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.

Exterior View Shown on Opposite Page.

the two developments. Should the plan of the prism be so placed on the sphere that all sides would be different, then two elevations would be necessary so that the intersections of all the sides could be shown.

Developments by Triangulation. In developing sheet-metal work of irregular forms, patterns are required which cannot be developed by either the parallel or radial-line methods. These irregular shapes are so formed that although straight lines can be drawn upon them the lines would not run parallel to one another, nor would they all incline to a common center. In the methods previously described, the lines in parallel developments run parallel to one another, while in radial-line developments all the lines meet at a common center. Hence in the development of any irregular article, it becomes necessary to drop all previous methods, and simply proceed to measure up the surface of the irregular form, part by part, and then add one to another until the entire surface is developed. To accomplish this, one of the simplest of all geometrical problems is made use of and shown in Part II of Mechanical Drawing, Plate V, Problem 11, entitled "To construct a triangle having given the three sides." To carry out this method it is necessary only to divide the surface of the plan or elevation of any irregular article into a number of equal parts. Use the distances in plan as the bases of the triangles, and the distances in elevation as the altitudes or heights of the triangles, or *vice versa;* and then find the hypothenuse by connecting the two given lengths.

To illustrate this simple principle Fig. 8 has been prepared. Let A B C D represent the plan of a plane surface, shown in elevation by A^1 B^1. We know that the true length of the plane is equal to A^1 B^1 and the true width is equal to A D or B C in plan. We also know that the vertical height from the bottom of the plane A^1 to the top B^1 is equal to B^1 *b* as shown. But suppose we want to obtain the true length of the diagonal line B D in plan on the developed plane. To obtain this it will be necessary only to take the length of B D, place it from *b* to D^1, and draw a line as shown from B^1 to D^1, which is the length desired.

While this may look very simple, it is all that there is to triangulation, and if the student thoroughly understands the simple principle and studies the problems which will follow, he will have

no trouble in applying this principle in complicated work. To make it still clearer we will prove the length of the line B^1 D^1. Take the distance of A^1 B^1, place it in plan as shown by A B^2, and complete the rectangle A B^2 C^2 D. Draw the diagonal B^2 D, being the length sought, which will be found to equal B^1 D^1 in elevation. When drawing this problem in practice, make the plan 4 by 6 inches and the vertical height in elevation 5 inches.

In obtaining developments by triangulation. the student should use all of his conceptive powers as previously explained. Before making any drawing, he must see the article before him in his mind's eye, so to speak, before he can put it down on paper. Therefore we want to impress upon the student the necessity of drawing all the problems that will follow in this part and in the Practical Workshop Problems. It should be understood that triangulation is not given as an alternative method, but is used when no other method can be employed, and without it no true pattern could be obtained for these irregular shapes, hence the necessity of close study.

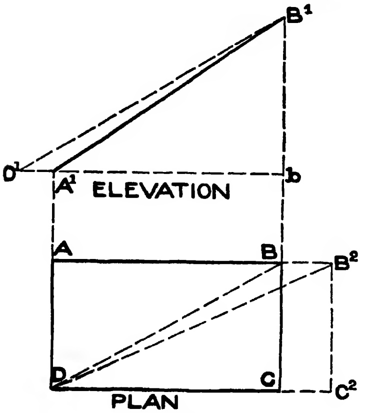


Fig. 8.

In Fig. 9 is shown an irregular solid whose base and top are triangles crossing each other, and in which the principle just explained will be put to practical test Inscribe the triangles shown in plan in a circle whose radius is equal to a 1. or $1\frac{1}{2}$ inches, and make the height of the article in elevation 2 inches. The dotted triangles 1 2 3 in plan represent the section of the article on the line 2–3 in elevation: and the solid triangle 1^1 2^1 3^1 in plan, the section on the line 2^1 3^1 in elevation. Now connect the two sections in plan by drawing lines from 1 to 2^1 and to 3^1, from 2 to 2^1 and to 1^1, and from 3 to 1^1 and to 3^1. In a similar manner connect the points in elevation as shown. It now becomes necessary to obtain a triangle giving the true length of the lines connecting the corners of the triangle in plan, and as all of these lines are equal only one triangle is necessary Therefore take the distance from

1 to 2^1 in plan and place it on the line 3–2 extended in elevation, as shown from 2 to 1°, and draw a line from 1° to 2^1, which is the desired length.

For the pattern, proceed as is shown in Fig. 10. Take the distance of any one of the sides in the triangle, as 1–2 in Fig. 9, and place it on the horizontal line 1–2 in Fig. 10. Then using 1 and 2 as centers, with 1° 2^1 in elevation in Fig. 9 as radius, describe the arcs in Fig. 10 intersecting each other in 2^1. Then 1 2 2^1 will be the pattern for one of the sides shown in plan in Fig. 9 by 1 2 2^1. Proceed in this manner in Fig. 10 as shown by the small arcs; or a tracing may be taken of the one side 1 2 2^1, and traced as shown until six sides are obtained, which will be the full pattern and which is numbered to correspond to the numbers in plan.

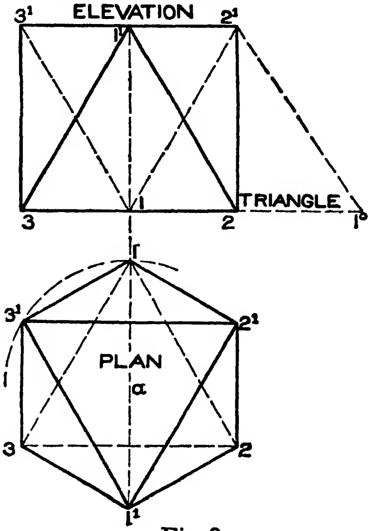


Fig. 9.

In Figs. 11, 12, and 13 are shown the methods used in developing a scalene cone. The method of obtaining the development of any scalene cone, even though its base is a perfect circle, is governed by the same principle as employed in the last problem on triangu-

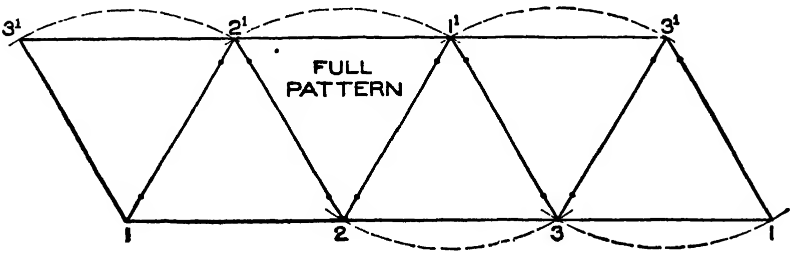


Fig. 10.

lation It is well to remember that any section of a scalene cone drawn parallel to its base will have the same shape (differing of course in size) as the base. This is equally true of articles whose

bases are in the shape of a square, rectangle, hexagon, octagon, or any other polygon. What has just been explained will be proven in connection with Fig. 11, in which A B C represents a side elevation of a scalene cone, whose plan is shown by 1 4^1 7 4 C^1. Draw any horizontal line, as A D, on which set off the distances

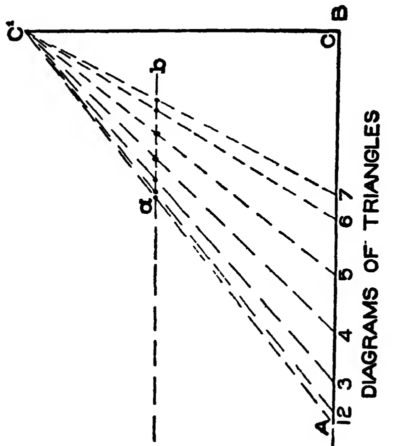


Fig. 12.

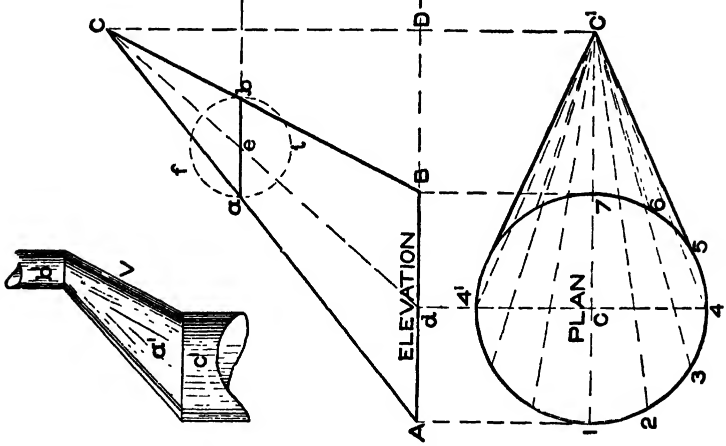


Fig. 11.

A B equal to 3 inches and B D equal to $2\frac{1}{2}$ inches, and the vertical height D C equal to $4\frac{1}{2}$ inches. Draw lines from B and A to C, which completes the elevation. In its proper position below the line A B, draw the plan of A B as 1 4 7 4^1 struck from the center C Through C draw the horizontal line C C^1, and

intersect it by a vertical line drawn from the apex C in elevation, thus obtaining the apex C^1 in plan. Draw lines from 4 and 4^1 to C^1, which completes the plan.

As both halves of the scalene cone are symmetrical, it is necessary only to divide the half plan 1 4 7 into a number of equal spaces as shown by the small figures 1 to 7, and from points thus obtained draw radial lines to the apex C^1. Then these lines in plan will represent the bases of triangles which will be constructed, whose altitudes are all equal to D C in elevation. Therefore in Fig. 12 draw any horizontal line, as A B, and from any point, as C, erect the perpendicular line C C^1 equal in height to D C in Fig. 11. Now from C^1 in plan take the various lengths of the lines 1 to 7 and place them on the line A B in Fig. 12, measuring in every instance from the point C, thus obtaining the intersections 1 to 7, from which lines are drawn to the apex C^1. Then these lines will represent the true lengths of similarly numbered lines in plan in Fig. 11.

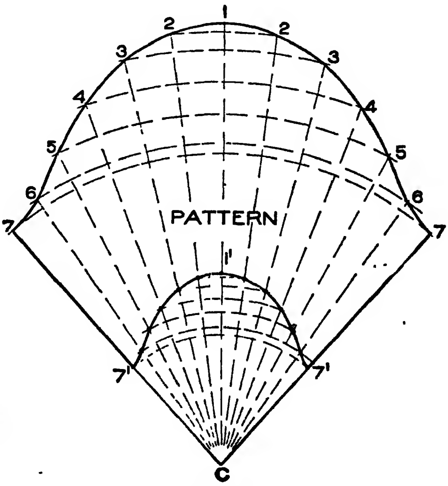


Fig. 13.

For the pattern proceed as is shown in Fig. 13. With C as center and radii equal to C^1 7, 6, 5, 4, etc., in Fig. 12, describe the arcs 7–7, 6–6, 5–5, 4–4, etc., in Fig. 13 as shown. Now assuming that the seam is to come on the short side of the cone, as C B in Fig. 11, set the dividers equal to one of the equal spaces in the plan; and starting on the arc 7–7 in Fig. 13, step from arc 7 to arc 6, to arcs 5, 4, 3, 2, and 1, and then continue to arcs 2, 3, etc., up to 7. Trace a line through these intersections as shown by 7–1–7, and draw lines from 7 and 7 to C, which completes the pattern.

Now to prove that any section of an oblique or scalene cone cut parallel to its base, has a similar shape to its base (differing in size), draw any line as *a b* in Fig. 11 parallel to A B. From C in

plan erect a vertical line intersecting the base line A B at *d*, from which draw a line to the apex C, cutting the line *a b* at *e*. Then the distances *e a* and *e b* will be equal; and using *e* as a center and *e b* as radius, describe the circle *a f b i*, which is the true section on *a b*. Then *a b* B A will be the frustum of a scalene cone. Extend the line *a b* parallel to A D, cutting the diagram of triangles in Fig. 12 from *a* to *b*. Then with radii equal to the distances from C^1 to the various intersections on the line *a b*, and using C in Fig. 13 as center, intersect similarly numbered radial lines drawn from 7 to 1 to 7 to the apex C. A line traced as shown from 7′ to 1′ to 7′ will be the desired cut, and 7–7–7′–7′ will be the pattern for the frustum. The practical use of this method is shown in diagram V in Fig. 11; *a′* is the frustum of the oblique cone, on the ends of which are connected round pipes *b′* and *c′*.

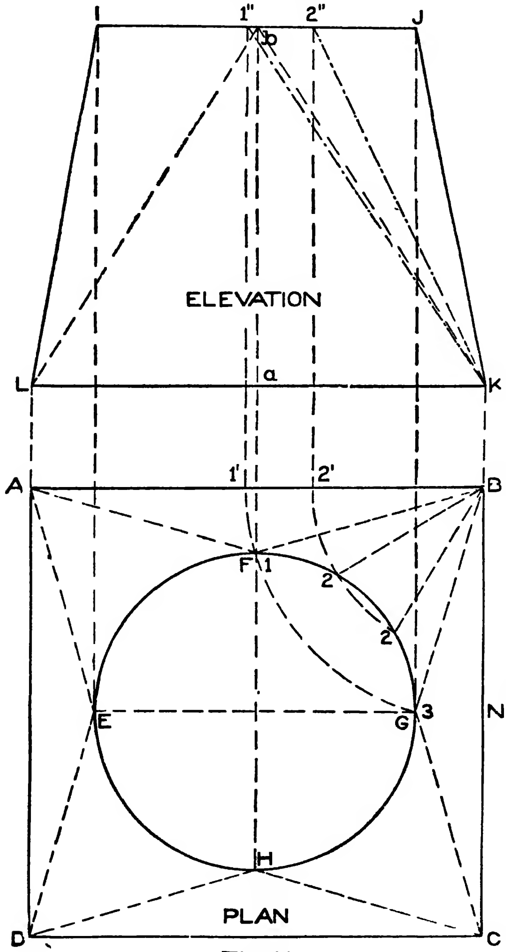


Fig. 14.

It is shown in Fig. 14 how in an irregular solid whose base is square and top is round, both top and bottom on horizontal planes are developed. The corners in plan F B G, G C H, H D E and E A F should be considered as sections of scalene cones. Proceed by drawing the plan A B C D $3\frac{1}{2}$ inches square, which represents the

plan of the base of the article; and the circle E F G H $2\frac{1}{2}$ inches in diameter, which shows the plan of the top of the article; the vertical height to be 3 inches, shown from *a* to *b*. As the circle is in the center of the square, making the four corners symmetrical, it is necessary only to divide the one-quarter circle into a number of equal parts as shown by the small figures 1, 2, 2, 3, from which draw lines to the apex B. Complete the elevation as shown by I J K L. Now using B as center, and radii equal to B 1 and B 2 in plan, describe arcs intersecting A B at 1′ and 2′ as shown. From these points erect perpendiculars intersecting the top of the article I J

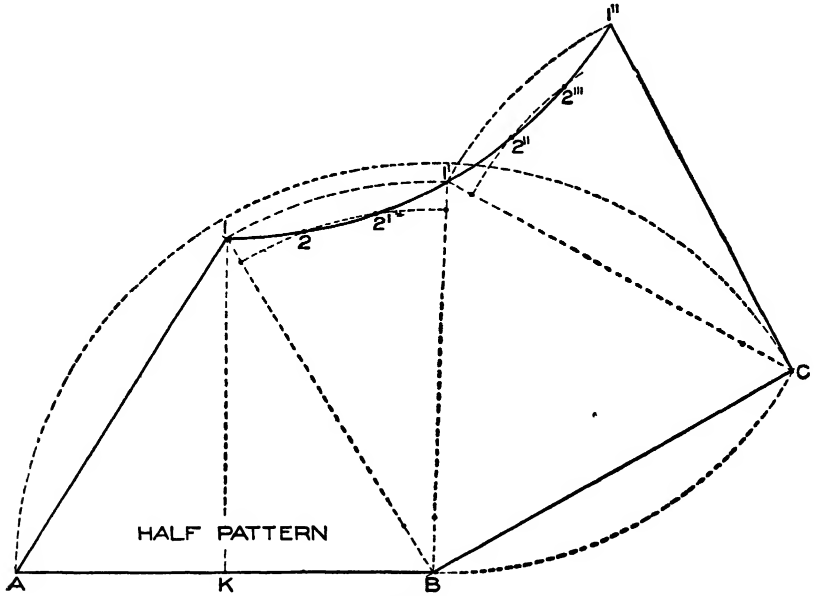


Fig. 15.

in elevation at 1″ and 2″, from which draw lines to K. Then K 1″ and K 2″ will be the true lengths of the lines shown in plan by B 1 and B 2 respectively on the finished article.

For the half pattern proceed as follows: In Fig. 15 draw any horizontal line, as A B, equal in length to A B in plan in Fig. 14. Now with K 1″ as radius and A and B in Fig. 15 as centers, describe arcs intersecting each other at 1 From 1 drop a vertical line intersecting A B at K. Then 1 K should equal J K in elevation in Fig. 14, which represents the true length through G N in plan.

Now with radii equal to K 1″ and K 2″ in elevation, and with B in Fig. 15 as center, describe the arcs 1–1′ and 2–2′. Now set the dividers equal to one of the spaces in G F in plan in Fig. 14; and starting at 1 in Fig. 15, step off arcs having similar numbers as shown by 1, 2, 2′, 1′. Now using 1 B as radius, and 1′ as center, describe the arc B C, and intersect it by an arc struck from B as center and with B A as radius, as shown at C. Take a tracing of 1 B 1′ and place it as shown by 1′ C 1″. Now connect the various intersections by drawing lines from 1 to A to B to C to 1″ to 1′ to 1, which completes the half pattern. The triangular pieces 1 A B or 1′ B C will represent the flat sides of the article shown in plan by 1 A B or 3 B C respectively in Fig. 14; and the cone patterns 1–1′ B and 1′–1″ C in Fig. 15, the sections of the scalene cones 1–3–B and H–G–C respectively in plan in Fig. 14. This same rule is applicable whether the top opening of the article is placed exactly in the center of the base or at one side or corner. Various problems of this nature will arise in Practical Workshop Problems; and if the principles of this last problem are thoroughly understood, these will be easily mastered.

Approximate Developments. In developing the blanks or patterns for sheet-metal work which requires that the metal be hammered or raised by hand, or passed between male and female dies in foot or power presses, circular rolls, or hammering machines, the blanks or patterns are developed by the approximate method, because no accurate pattern can be obtained. In all raised or pressed work in sheet metal, more depends upon the skill that the workman has with the hammer, than on the patterns, which are but approximate at their best. While this is true, it is equally true that if the workman understands the scientific rule for obtaining these approximate patterns a vast amount of time and labor can be saved in bringing the metal to its proper profile. If the true rule for averaging the various shapes and profiles in circular work is not understood, the result is that the blank has either too little or too great a flare and will not form to its proper profile and curve. Before proceeding to describe the approximate development methods, attention is called to the governing principle underlying all such operations. We have previously shown how the patterns are developed for simple flaring ware; in other words, how to

develop the frustum of a cone. The patterns for curved or any other form of circular or hammered work are produced upon the same principle. The first illustration of that principle is shown in Fig. 16, in which A B C D represents a sphere 3 inches in diameter composed of six horizontal sections, struck from the center *a*.

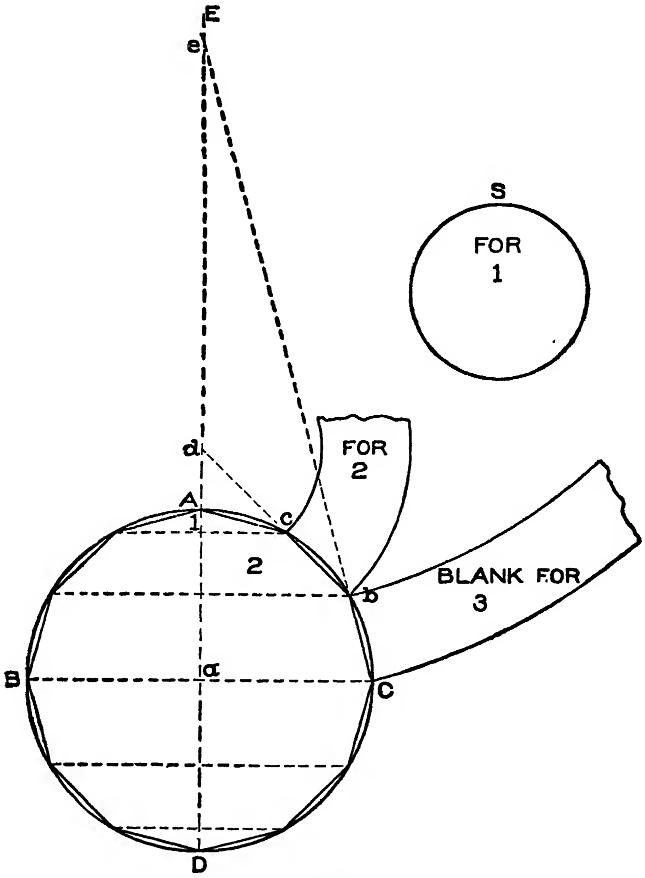


Fig. 16.

Divide the quarter circle A C into as many parts as there are sections required in the half sphere (in this case three), and draw horizontal lines through the ball as shown. The various radii for the patterns are then obtained by drawing lines through C *b*, *b c*, and *c* A. Thus C *b* extended meets the center line E D at *e*, which

is the center for striking the blank for number 3, using the radii *e b* and *e* C. In similar manner draw a line from *b* to *c*, extending it until it meets E D at *d*. Then *d c* and *d b* will be the radii for blank number 2, while A *c* is the radius for blank 1 shown at S The lengths of the pattern pieces are determined in the same manner as would be the case with an ordinary flaring pan in producing the patterns for tin ware, and will be explained

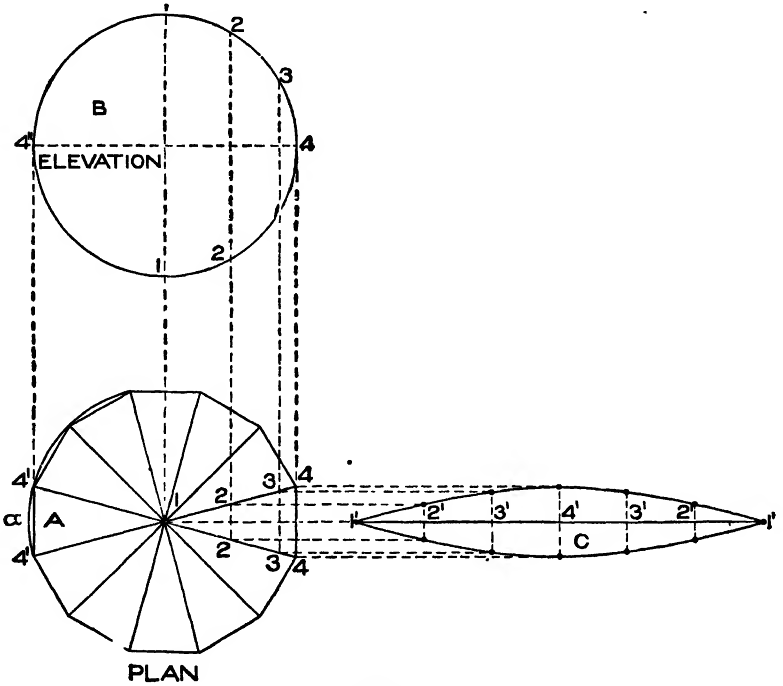


Fig. 17.

thoroughly in the Practical Workshop Problems which will shortly follow.

In Fig. 17 is shown another elevation of a sphere composed of twelve vertical sections as shown in plan view. While the method used for obtaining the pattern is by means of parallel lines, and would be strictly accurate if the sections in plan remained straight as from 4 to 4, the pattern becomes approximate as soon as we start to raise it by means of machine or hammer to conform to the profile B in elevation, because the distance along the curve *a* from 4′ to 4′

in plan is greater than a straight distance from 4 to 4. The pattern by this method is obtained as follows: Let B represent the elevation of the sphere, and A the plan of the same, which is divided into as many sides as the sphere is to have vertical sections, in this case 12, being careful that the two opposite sides 4–4 and 4′ 4′ in plan run parallel to the center line as shown. Make the diameter of the sphere 4–4″ 3 inches. Divide the half elevation into an equal number of spaces as shown from 1 to 4 to 1, and from these points drop lines at right angles to 4–4″ intersecting the miter lines 1–4 in plan as shown. Now draw any horizontal line, as 1′–1′, upon which place the stretchout of 1–4–1 in elevation as shown by 1′–4′–1′ on the line 1′–1′ in C. Through these points draw lines at right angles to 1′–1′, which intersect by lines drawn from similarly numbered intersections on the miter lines 1–4 in plan, at right angles to 4–4. A line traced through points thus obtained as shown by C will be the desired pattern.

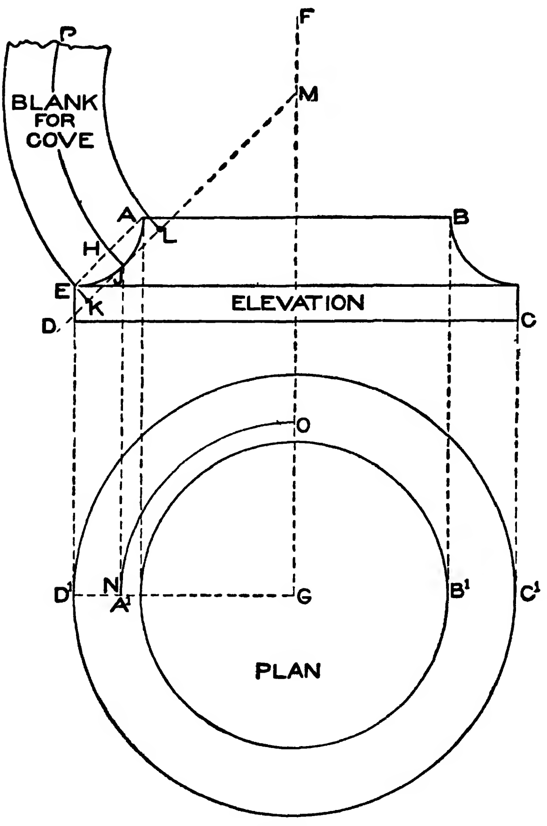


Fig. 18.

In Fig. 18 is shown the principle used in obtaining the radii with which to develop the blank for a curved or circular mould when it is to be hammered by hand. In this connection, only the principle employed will be shown, leaving the full development and also the development for patterns which are to be raised by hand

and hammered by machine, to be explained in problems which will follow in Practical Workshop Problems. Draw this problem double the size shown. First draw the elevation A B C D, and through the elevation draw the center line F G. Then using G as a center, draw the circles A^1 B^1 and C^1 D^1 representing respectively the horizontal projections of A B and C D in elevation. Now draw a line from A to E in elevation, connecting the corners of the cove as shown. Bisect A E and obtain the point H, from which at right angles to A E draw a line intersecting the cove at J. Through J parallel to A E draw a line intersecting the center line F G at M. Take the stretchout from J to A and from J to E and place it on the line J M as shown respectively from J to L and from J to K. Then will M L and M K be the radii with which to strike the pattern or blank for the cove. From J drop a vertical line intersecting the line D^1 G in plan at N. Then with G as center strike the quarter circle N O. Now using M as center and M J as radius, strike the arc J P. Then on this arc, starting from J, lay off 4 times the stretchout of N O in plan for the full pattern. It should be understood that when stretching the cove A E, the point J remains stationary and the metal from J to L and from J to K is hammered respectively toward J A and J E. For this reason is the stretchout obtained from the point J.

PRACTICAL WORKSHOP PROBLEMS.

In presenting the 32 problems which follow on sheet-metal work, practical problems have been selected such as would arise in every-day shop practice.

In this connection we wish to impress upon the student the necessity of working out each and every one of the 32 problems. Models should be made from stiff cardboard, or, if agreeable to the proprietor of the shop, the patterns can be developed at home, then cut out of scrap metal in the shop during lunch hour, and proven in this way.

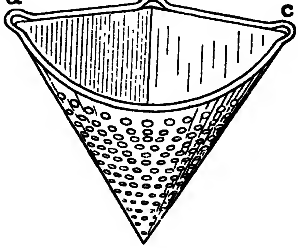


Fig. 19.

Our first problem is shown in Fig. 19, and is known as a sink drainer. It is often the case that the trap under the kitchen sink

is choked or blocked, owing to a collection of refuse matter. To avoid this a sink drainer is used, and is fastened in position through the wire loops *a*, *b* and *c*. The refuse matter is poured into the drainer, from which it is easily removed after the fluid has passed through the perforations. These drainers may be made of tin or of black or galvanized iron, but where a good job is wanted 16-ounce copper should be used. To obtain the pattern for any sized drainer, proceed as follows: First draw the plan of the drainer A B C in Fig. 20, making A B and B C each two inches and forming a right angle. Then using B as center and A B as radius, draw the arc A C. In its proper position above the plan construct the side elevation, making E D 2 inches high, and draw the line F D. Then will F E D be the side elevation. Divide the arc A C into equal spaces as shown by the small figures 1 to 5. For the pattern use F D as radius, and with D in Fig. 21 as center strike the arc 1 5. From 1 draw a line to D and step off on 1–5 the same number of spaces as contained in A C in plan in Fig. 20, as shown by similar figures in Fig. 21. Draw a line from 5 to D. Then will 1–5–D be the pattern for the front of the strainer, in which perforations should be punched as shown. To join the sides of this pattern, use 1 and 5 as centers, and with either F E or A B in Fig. 20 as radius, describe the arcs E and E^1 in Fig. 21. Now using D as center and D E in Fig. 20 as radius, intersect the arcs E and E^1 as shown in Fig. 21. Draw lines from 1 to E^1 to D to E to 5, which completes the pattern, to which edges must be allowed for wiring at the top and seaming at the back.

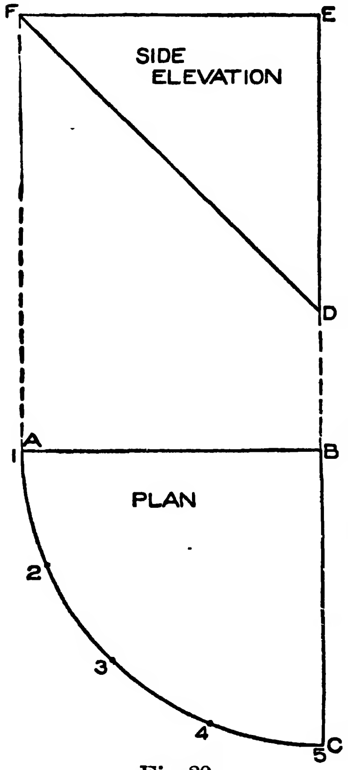


Fig. 20.

When joining a faucet or stop cock to a sheet-metal tank it is usual to strengthen the joint by means of a conical "boss," which

is indicated by A in Fig. 22. In this problem the cone method is employed, using principles similar to those used in developing a frustum of a cone intersected by any line. Therefore in Fig. 23 let

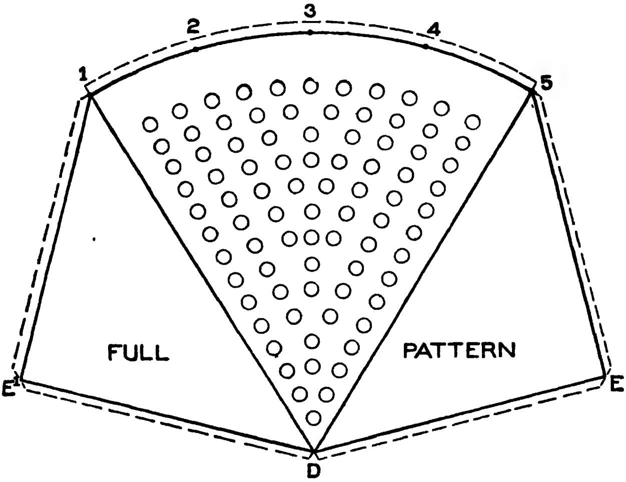


Fig. 21.

A B represent the part plan of the tank, C portion of the faucet extending back to the tank line, and F G H I the conical "boss" to fit around a faucet. When drawing this problem make the radius of the tank D A equal to $3\frac{1}{2}$ inches, and from D draw the vertical line D E. Make the distance from G to H equal to $2\frac{3}{4}$ inches, the diameter of the faucet F I $1\frac{1}{4}$ inches and the vertical height K C $1\frac{1}{2}$ inches Draw a line from G to H intersecting the center line D E at K. Then using K as center describe the half section G J H as shown. Divide J H into equal parts shown from 1 to 4, from which drop vertical lines intersecting the line G H as shown, from which draw radial lines to the apex E cutting the plan line

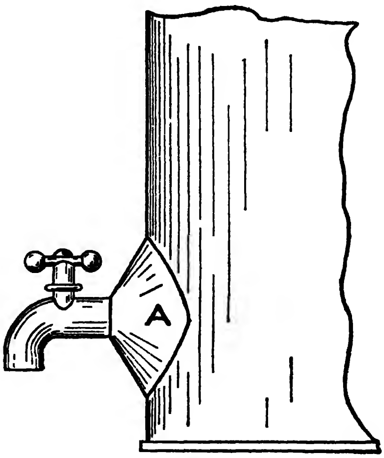


Fig. 22.

of the tank A B as shown. From these intersections draw horizontal lines intersecting the side of the cone H I at 1, 2′, 3′, and 4′. Now use E as center, and with radius equal to E 1 describe the

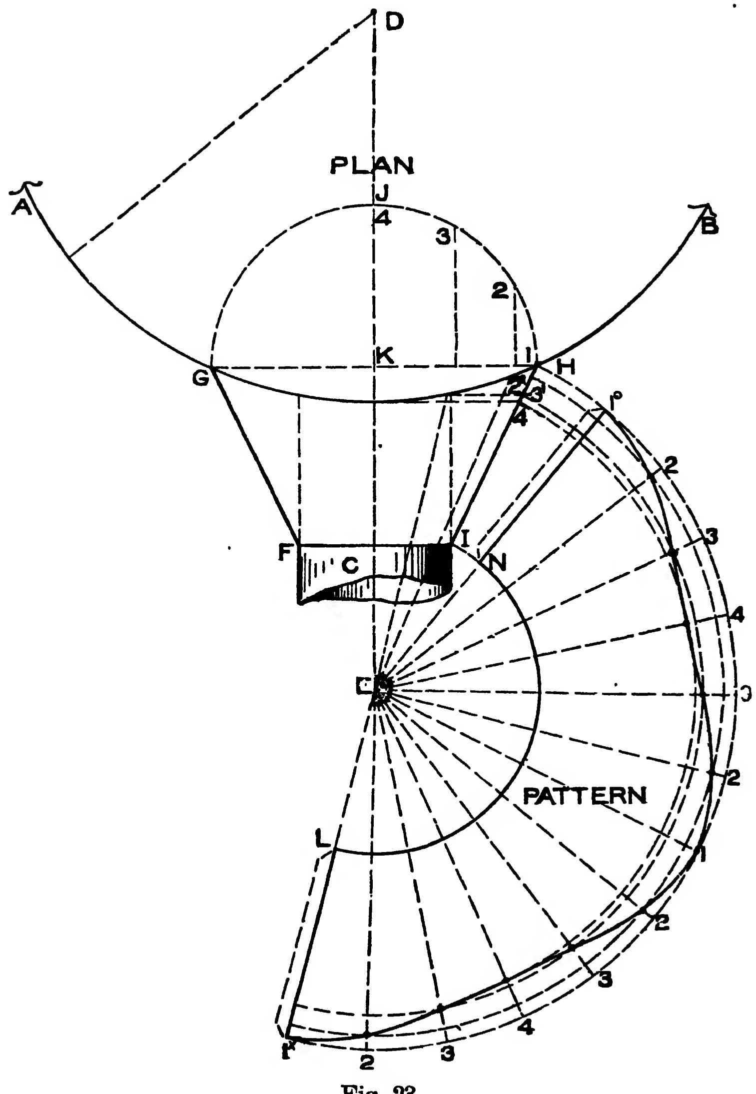


Fig. 23.

arc 1°–1x as shown. Draw a line from 1° to E, and starting from 1° set off on 1°–1x four times the number of spaces contained in

J H in plan, as shown by similar numbers on 1° 1^x. Draw a line from 1^x to E, and with E I as radius describe the arc N L intersecting the radial lines 1° E and 1^x E at N and L respectively. From the various numbers on the arc 1° 1^x draw radial lines to the apex E; and using E as center and with radii equal to E 4′, E 3′, and E 2′, draw arcs intersecting similarly numbered radial lines as shown. Trace a line through points thus obtained; then will N 1° 1 1^x L be the pattern for the "boss."

In Fig. 24 is shown what is known as a hip bath. In drawing out the problem for practice the student should remember that it is similar to the preceding one, the only difference being in the outline of the cone. Make the top of the cone I B in Fig. 25 equal to 3¼ inches, the bottom C D 1¾ inches, the vertical height from K to 5′ 2½ inches, the diameter of the foot E F 2¼ inches, and the vertical height 5′–5″ ¼-inch. Through the center of the cone draw the center line K L, and at pleasure draw the outline of the bath as shown by A J B. It is immaterial of what outline this may be, the principles that follow being applicable to any case. Thus, in the side elevation, extend the lines B C and A D until they intersect the center line at L. In similar manner extend the sides of the foot-piece E D and F C until they intersect the center line at R. Now with 5′ as center and with radius equal to 5′ D or 5′ C, describe the half section C H D, which divide into equal spaces as shown by the small figures 1 to 9. From the points of division erect vertical lines meeting the base line of the bath D C at points 1, 2′, 3′, etc., to 9. From the apex L and through these points draw radial lines intersecting the outline B J A, from which horizontal lines are drawn intersecting the side of the bath B C as shown from 1 to 9. For the pattern for the body use L as center, and with L C as radius draw the arc F L^1. Now starting at any point, as 1, set off on F L^1 twice the stretchout of D H C as shown by similar numbers on the arc F L^1. From the apex L and through the small figures draw radial lines, which intersect by arcs

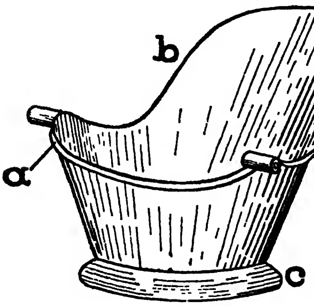
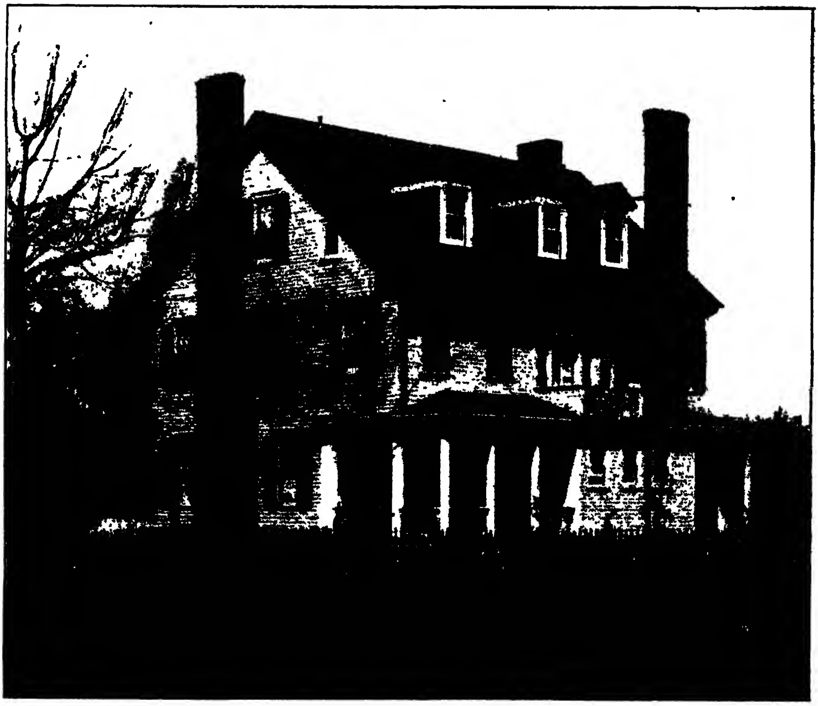


Fig. 24.

FRONT AND REAR VIEWS OF RESIDENCE OF MR. H. T. LOOMIS, MAGNOLIA DRIVE, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

Cost, about $35,000. First-Story Walls of McCausland Brick, Made at Akron, Ohio. Roofs of Combination Red Tile.



FRONT AND REAR VIEWS OF RESIDENCE OF MRS. H. M. COBB, MAGNOLIA DRIVE, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

struck from L as center with radii equal to similarly numbered intersections on B C. Trace a line through points thus obtained, and L^1 M N P F will be the pattern for the body of the bath to which laps should be added at the bottom and sides for seaming.

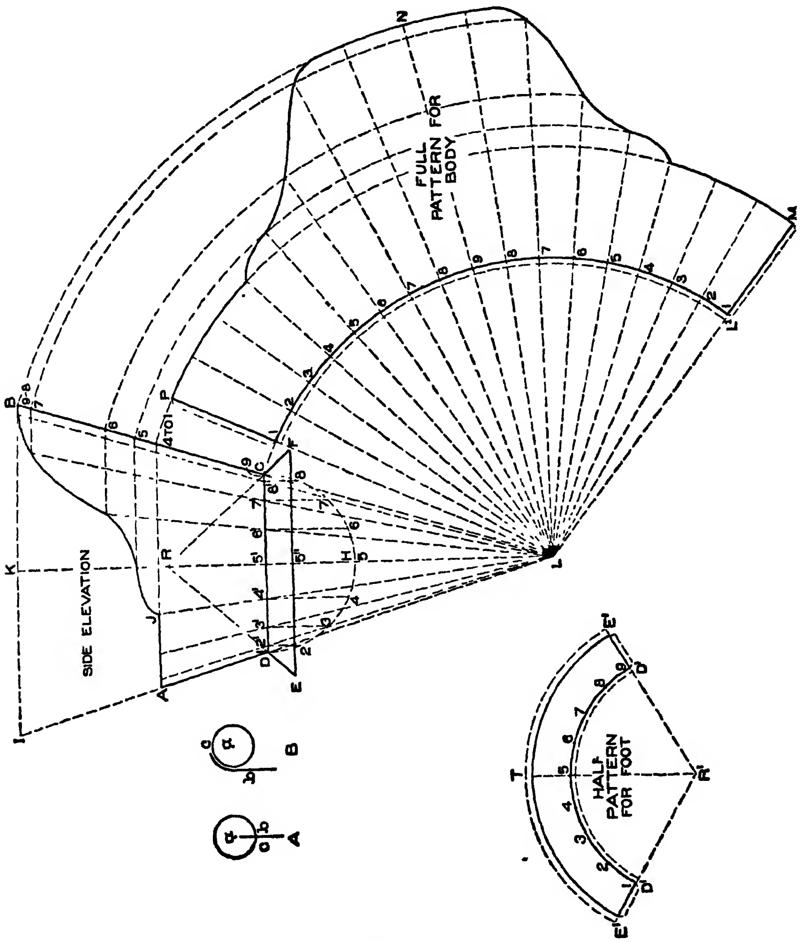


Fig. 25.

The pattern for the foot is obtained by using as radii R D and R E, and striking the pattern using R^1 as center, the half pattern being shown by E^1 T E^1 D^1 D^1, and the distance D^1 D^1 being equal to the stretchout of the half section D H C in side elevation.

It is usual to put a bead along the edges of the top of a bath as shown at *a* and *b* in Fig. 24. For this purpose tubing is sometimes used, made of brass, zinc, or copper and bent to the required shape; or zinc tubes may be rolled and soldered by hand, filled with heated white sand or hot rosin, and bent as needed. The tube or bead can be soldered to the body as shown in (A) in Fig. 25. Here *a* represents the bead, in which a slot is cut as *c*, and which is then slipped over the edge of the bath and soldered. Another method is shown in (B), in which the bath body *b* is flanged over the bead *a* and soldered clean and smooth at *c*, being then scraped and sandpapered to make a smooth joint. A wired edge is shown at *c* in Fig. 24, for which laps must be allowed as shown in Fig. 25 on the half pattern for foot.

In Fig. 26 is shown the perspective view of a bath tub; these tubs are usually made from IX tin or No. 24 galvanized iron. The bottom and side seams are locked and thoroughly soldered, while the top edge is wired with handles riveted in position as shown at A. The method used in developing these patterns will be the cone method and triangulation. In drawing this problem for practice (Fig. 27), first draw the center line W 8 in plan; and using *a* as center with a radius equal to 1½ inches draw the semicircle C–12 D. Now make the distance *a* to *b* 4 inches; and using *b* as center with a radius of 1⅝ inches draw the semicircle E–7–H. Draw lines from E to D and from C to H. D E 7 H C 12 D will be the plan of the bottom of the bath. In this case we assume that the flare between the top and bottom of the narrow end of the bath should be equal; therefore using *a* as center and with a radius equal to 1⅝ inches draw the semicircle A W B. At the upper end of the bath the flare will be unequal; therefore from *b* measure a distance on line W 8 of 1 inch and obtain *c*, which use as center, and with a radius equal to 2 inches describe the arc F 8 G. Draw lines from F to A and from B to G; and A F 8 G B W A will be the plan of the top of the bath. Now project the side elevation from the plan as shown by the dotted lines, making the slant height from I to R 2⅛ inches and from J to K 3⅛ inches; draw a line

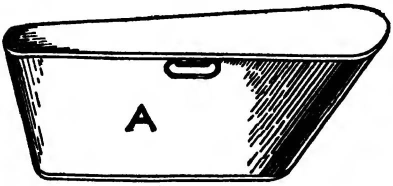


Fig. 26.

from K to R, and J K R I will be the side elevation of the bath tub. In constructing the bath in practice, seams are located at H G, F E,

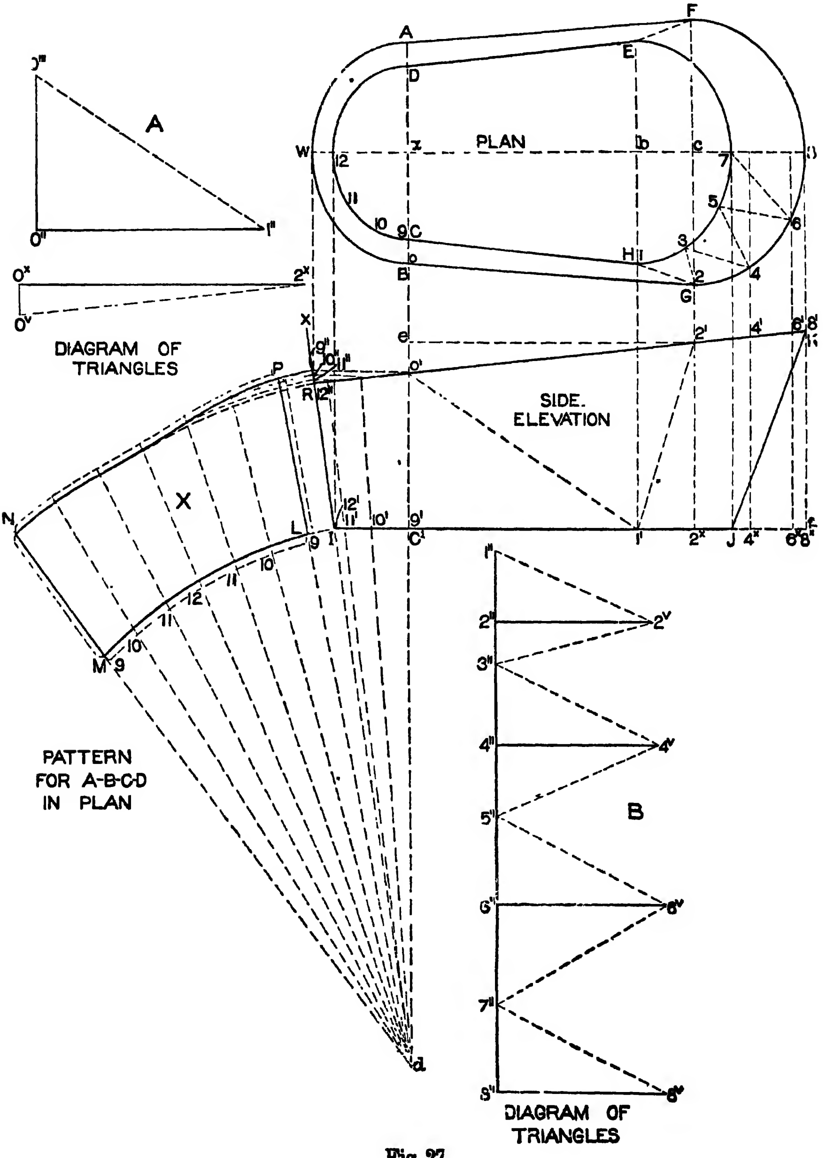


Fig. 27.

A D, and C B in plan, thus making the tub in four pieces

The lower end of the bath will be developed by the cone method as in the last two problems. From the center *a* drop a line indefinitely as shown. Extend the side R I of the side elevation until it meets the center line *a d* at *d*. Now divide the quarter circle 12–9 in plan into equal spaces as shown by the small figures 9, 10, 11, and 12, from which drop vertical lines (not shown) intersecting the bottom of the bath tub in elevation from 9′ to 12′. Then through these points from *d* draw lines intersecting the top line of the bath R K as shown, from which draw horizontal lines intersecting the side I–R extended as I X at points 9″ to 12″. Then using *d* as center and *d* I as radius, describe the arc I M, upon which place the stretchout of D 12 C in plan, as shown by similarly numbered points on L M. Through these points from *d* draw radial lines, which intersect by arcs drawn from similarly numbered intersections on I R extended, using *d* as center. Trace a line as shown, and L M N P will be the pattern for the lower end of the tub A B C D in plan. Laps should be allowed for wiring and seaming.

As the patterns for the upper end and sides will be developed by triangulation, diagrams of triangles must first be obtained, for which proceed as follows: Divide both of the quarter circles H 7 and G 8 in plan into the same number of spaces as shown respectively from 1 to 7 and from 2 to 8. Connect these numbers by dotted lines as shown from 1 to 2, 2 to 3, 3 to 4, etc. From the various points 2, 4, 6, and 8 representing the top of the bath, drop lines meeting the base line J *f* in elevation at 2^x, 4^x, 6^x, and 8^x, and cutting the top line of the bath at 2′, 4′, 6′, and 8′. Then will the dotted lines in plan represent the bases of the triangles, which will be constructed, whose altitudes are equal to the various heights in elevation. Take the various distances 1 to 2, 2 to 3, 3 to 4, 4 to 5, etc., in plan up to 8, and place them on the vertical line 1″–8″ in (B) as shown from 1″ to 2″, 2″ to 3″, 3″ to 4″, 4″ to 5″, etc., up to 8″. For example, to obtain the true length of the line 6–7 in plan, remembering that the points having even numbers represent the top line of the bath and those having uneven numbers the base line, draw at right angles to 1″–8″ in (B), from 6″, a line equal in height to 6^x–6′ in elevation, and draw a line from 6^v to 7″ in (B), which is the length desired. For the true

length of 6–5 in plan it is necessary only to take this distance place it from 6″ to 5″ in (B) and draw a line from 6^{v} to 5″. In this way each altitude answers for two triangles. In plan draw a line from 1 to 0. Then will two more triangles be necessary, one on the line 1–0, and the other on B G or 0–2. From 2′ in elevation draw a horizontal line, as 2′ *e*, intersecting the vertical line dropped from 0 at *e*. Now take the distances 0 1 and 0 2, and place them in (A) as shown by the horizontal lines 0″–1″ and 0^{x}–2^{x} respectively. At right angles to both lines at either end draw the vertical lines 0″–0‴ and 0^{x}–0^{v} equal in height respectively to C^{1} 0′ and *e* 0′ in elevation. Draw in (A) lines from 2^{x} to 0^{v} and from 1″ to 0‴, which are the desired lengths. Before proceeding with the pattern, a true section must be obtained on 2′–8′ in side elevation. Take the various distances 2′ to 8′ and place them on the line 2′–8′ in Fig. 28. At right angles to 2′–8′ and through the small figures draw lines as shown. Now measuring in each and every instance from the center line in plan in Fig. 27, take the various distances to points 2, 4, and 6 and place them on similarly numbered lines in Fig. 28, measuring in each case on either side of the line 2′–8′, thus obtaining the intersections 2–4–6. A line traced through these points will be the true section on 2′–8′ in elevation in Fig. 27.

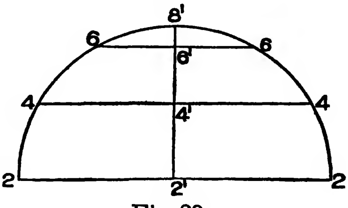


Fig. 28.

For the pattern for the upper end of the tub proceed as follows: Take the distance of 7″–8^{v} in (B) and place it on the vertical line 7–8 in Fig. 29. Then using 8 as center and with a radius equal to 8′–6 in Fig. 28, describe the arc 6 in Fig. 29, which intersect by an arc struck from 7 as center and with 7″–6^{v} in (B) in Fig. 27 as radius. Then using 7–5 in plan as radius, and 7 in Fig. 29 as center, describe the arc 5, which intersect by an arc struck from 6 as center and with 6^{v}–5″ in (B) in Fig. 27 as radius. Proceed in this manner, using alternately as radii first the divisions in Fig. 28, then the length of the slant lines in (B) in Fig. 27, the divisions on 7 H in plan, then again the slant lines in B, until the line 1–2 in Fig. 29 is obtained. Trace a line through points thus obtained, as shown by 2–8–7–1. Trace this opposite the line 8–7, as shown

by 2′ 1′. Then will 2–8–2′–1′–7–1 be the desired pattern, to which laps must be allowed.

For the pattern for the side of the bath draw any line 9–1 in Fig. 30 equal to 9–1 in plan in Fig. 27. Now with a radius equal

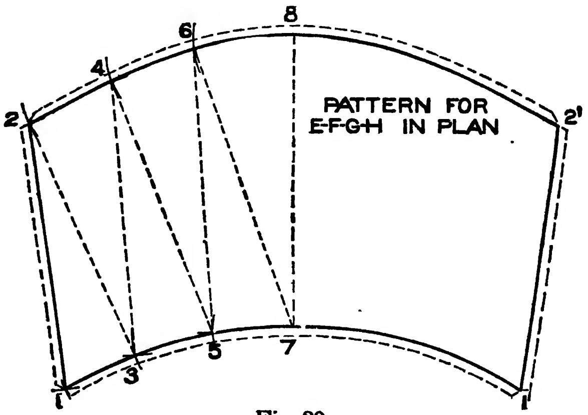


Fig. 29.

to 9–P in the pattern X and with 9 in Fig. 30 as a center, describe the arc 0, which intersect by an arc struck from 1 as center and with 1″–0‴ in (A) in Fig. 27 as radius. Now taking a radius equal to 0^v–2^x in (A) with 0 in Fig. 30 as center, describe the arc 2, which intersect by an arc struck from 1 as center, and with 1–2 in Fig. 29 as radius. Draw lines from corner to corner in Fig. 30, which gives the desired pattern, to which laps are added for seaming and wiring.

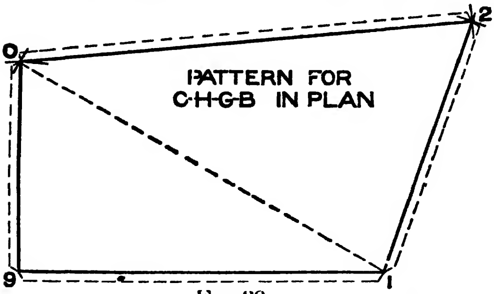


Fig. 30.

In Fig. 31 is shown a perspective view of a funnel strainer pail. These pails are usually made from IX bright tin, and the same principles as are used in the development of the pattern are applicable to similar forms, such as buckets, coal hods, chutes, etc. This problem presents an interesting study in triangulation, the principles of which have been explained in previous problems. First draw the center line C I in Fig. 32, at right angles to which

draw H E and H F each equal to $1\frac{1}{4}$ inches. Make the vertical height H C $3\frac{1}{4}$ inches and C D 2 inches. Now make the vertical heights measuring from C G, to A, and to B respectively $1\frac{1}{4}$ inches, and $1\frac{1}{2}$ inches. Make the horizontal distance from C to G $2\frac{3}{4}$ inches, the diameter from G to A $1\frac{3}{8}$ inches, and from A to B $\frac{3}{4}$-inch, and draw a line from B to C. Connect points by lines; then will A B C D E F G be the side elevation of the pail. In its proper position below F E, with J as center, draw the plan K L M N. Also in its proper position draw the section on A G as O P R S Now draw the rear elevation making G^1 U and G^1 V each equal to H E, and 1″ T and 1″–1′ each equal to C D. Project a line from B in side, intersecting the center line in rear at 4′. Then through the three points 1′ 4′ T draw the curve at pleasure, which in this case is struck from the center *a*. W Y X Z represents the opening on G A in side obtained as shown by the dotted lines but having no bearing on the patterns. Pails of this kind are usually made from two pieces, with seams at the sides, as in Fig. 31. The pattern then for the back shown by C D E H in side elevation in Fig. 32 will be obtained by the cone method, struck from the center I, the stretchout on E^1 E^2 in the pattern being obtained from the half plan. The pattern for C D E H is shown with lap and wire allowances by D^1 D^2 E^2 E^1 and needs no further explanation.

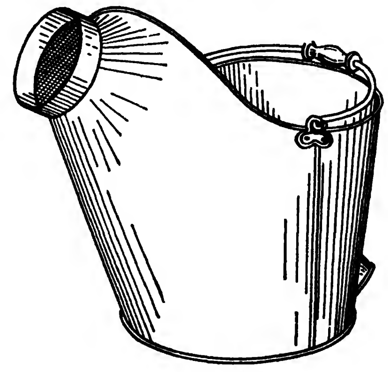


Fig. 31.

The front part of the pail shown by A B C H F G will be developed by triangulation, but before this can be done a true section must be obtained on B C, and a set of sections developed as follows: Divide one-half of 1′ 4′ T in rear elevation into equal parts as shown from 1′ to 4′, from which draw horizontal lines intersecting the line B C as shown. From these intersections lines are drawn at right angles to B C equal in length to similarly numbered lines in rear as 3′–3″, 2′–2″, and 1′–1″. Trace a line as shown, so that C 1‴ 2‴ 3‴ 4‴ will be the true half section on B C. To avoid a confusion of lines take a tracing of A B C H F G

and place it as shown by similar letters in Fig. 33. Now take tracings of the half sections in Fig. 32, as H E D C, C 1‴ B, P O S, and the quarter plan N J M, and place them in Fig. 33 on similar lines on which they represent sections as shown respectively by H 9′ 8′ C, C 8 B, A 3 G, and F 9 H. Divide the half section

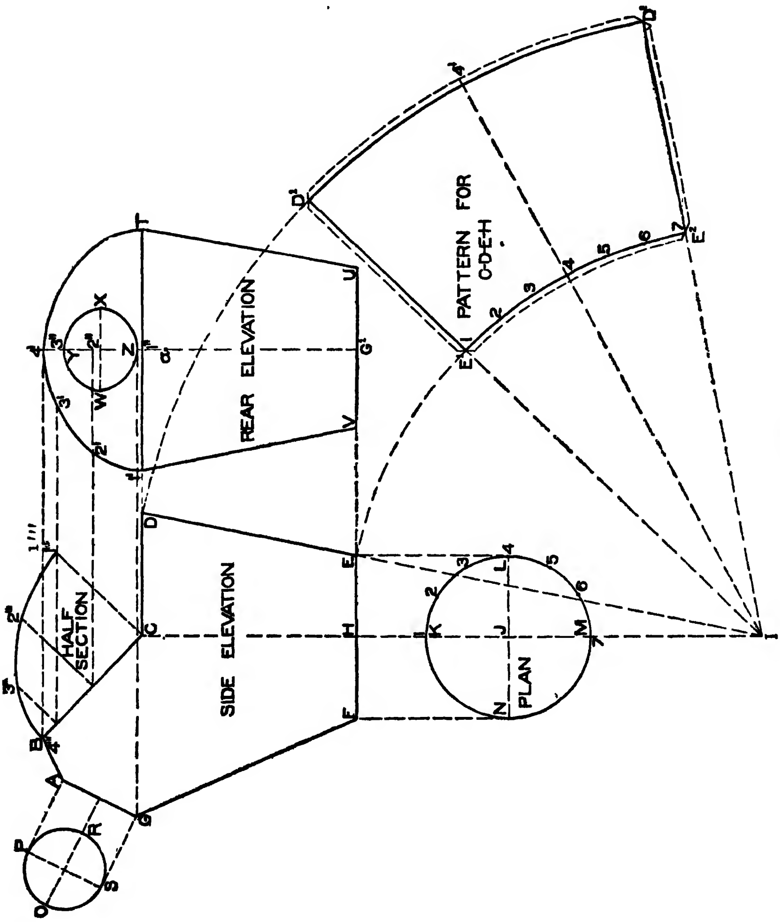


Fig. 32.

A 3 G into 6 equal parts as shown by the small figures 1 to 5. As this half section is divided into 6 parts, then must each of the sections B 8 C and F 9 H be divided into 3 parts as shown respectively from 6 to 8 and 9 to 11. As C 8′ and H 9′ are equal respectively to C 8 and H 9 they are numbered the same as shown.

Now at right angles to G A, B C, C H, and H F, and from the various intersections contained in the sections G 3 A, B 8 C, C 8′ 9′ H, and H 9 F, draw lines intersecting the base lines of the sections G A, B C, C H, and H F at points shown from 1′ to 11′. Now draw dotted lines from B to 5′ to 6′ to 4′ to 7′ to E to C, and then from H to E to 10′ to 2′, etc until all the points are

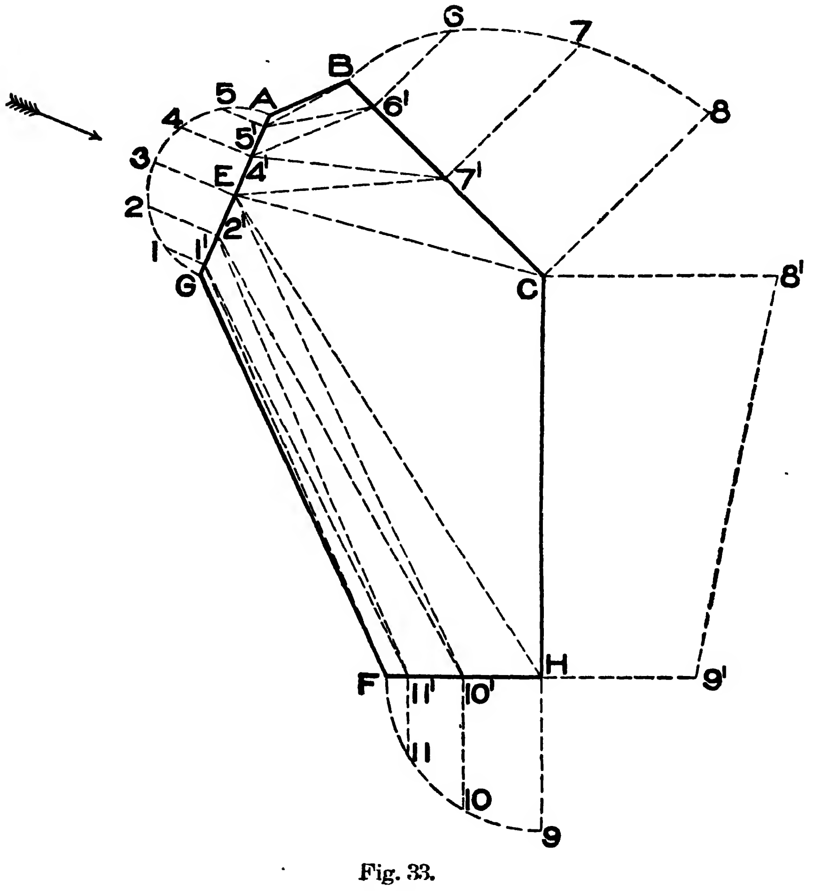


Fig. 33.

connected as shown. These dotted lines represent the bases of the sections whose altitudes are equal to similar numbers in the various sections.

In order that the student may thoroughly understand this method of triangulation as well as similar methods that will follow

in other problems, the model in Fig. 34 has been prepared, which shows a perspective of Fig. 33 with the sections bent up in their proper positions. This view is taken on the arrow line in Fig. 33, the letters and figures in both views being similar. For the true sections on the dotted lines in C E A B in Fig. 33, take the lengths of the dotted lines C E, E 7′, 7′ 4′, etc., and place them on the horizontal line in Fig. 35 as shown by similar letters and figures. From these small figures, at right angles to the horizontal line, erect the vertical heights C 8, E 3, 7′ 7, etc., equal to similar

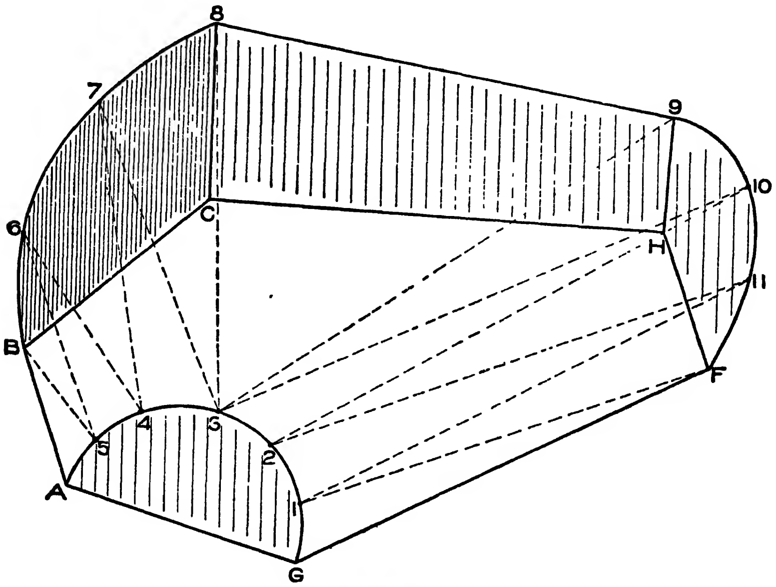


Fig. 34.

vertical heights in the sections in Fig. 33. Connect these points in Fig. 35 by dotted lines as shown, which are the desired true distances.

In Fig. 36 are shown the true sections on dotted lines in G E H F in Fig. 33, which are obtained in precisely the same manner, the only difference being that one section is placed inside of another in Fig. 36. For the pattern proceed as is shown in Fig. 37. Draw any vertical line as G F equal to G F in Fig. 33. With radius equal to G 1 and with G in Fig. 37 as center describe the arc 1, which intersect by an arc struck from F as center and

with a radius equal to F 1 in Fig. 36. Now with F 11 in Fig. 33 as radius and F in Fig. 37 as center, describe the arc 11, which is intersected by an arc struck from 1 as center and with 1–11 in Fig 36 as radius. Proceed in this manner until the line 3–9 in Fig. 37 has been obtained. Then using 8′–9′ in Fig. 33 as radius and 9 in Fig. 37 as center, describe the arc 8, which is intersected by an arc struck from 3 as center and with 3–8 in Fig.

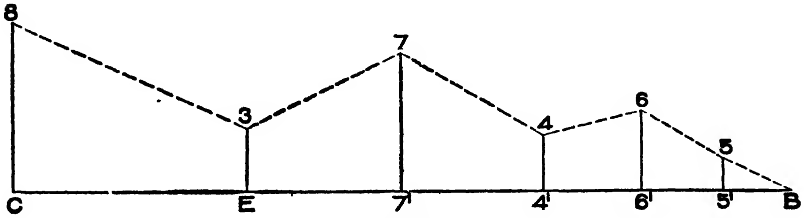


Fig. 35.

35 as radius. Now use alternately as radii, first the divisions in B 8 C in Fig. 33, then the length of the slant lines in Fig. 35, the divisions in E 3 A in Fig. 33, and again the distances in Fig. 35, until the line B A in Fig. 37 has been obtained, which is obtained from B A in Fig. 33. Trace a line through points thus obtained in Fig. 37 as shown by A B 8 9 F G A. Trace this half pattern opposite the line G F. Then will B A G A^1 B^1 8^1

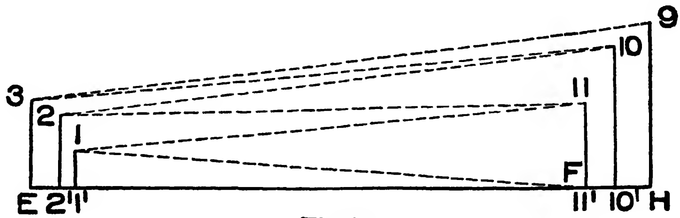


Fig. 36

9^1 F 9 8 be the pattern for the front half of the pail. If for any reason the pattern is desired in one piece, then trace one half of D^1 D^2 E^2 E^1 in Fig. 32 on either side of the pattern in Fig. 37 as shown by the dotted lines 8′ D^1 E^1 9^1 and 9 E D 8. Allow edges for wiring and seaming.

Fig 38 shows the method for obtaining the pattern for an Emerson ventilator shown in Fig. 39.

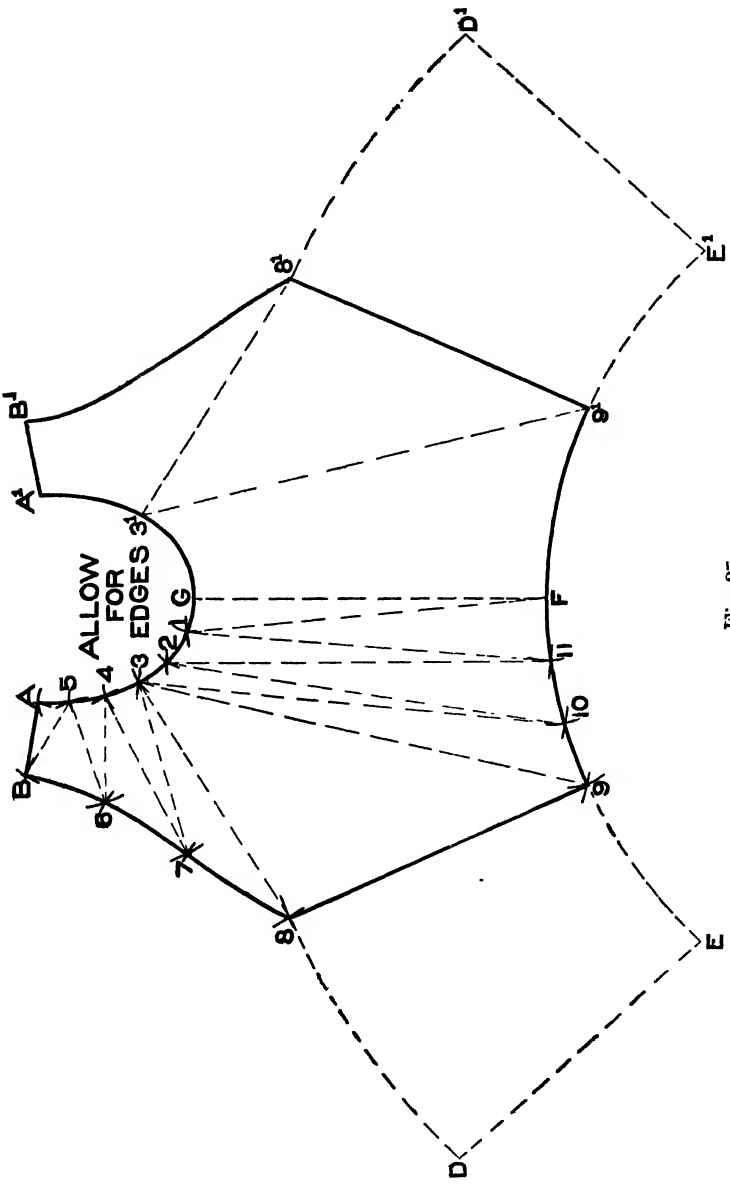


Fig. 37.

While the regular Emerson ventilator has a flat disc for a hood it is improved by placing a cone and deflector on the top as shown. To make the patterns, proceed as shown in Fig. 38. First draw the center line *a b*, on either side of which lay off

1½ inches, making the pipe A, 3 inches in diameter. The rule usually employed is to make the diameter of the lower flare and upper hood twice the diameter of the pipe. Therefore make the diameter of *s d* 6 inches. From *s* and *d*, draw a line at an angle of 45° to intersect the line of the pipe at *t* and *i*; this completes B. Measure 2 inches above the line *t i* and make *u m* the same diameter as *s d*. Draw the bevel of the deflector so that the apex will be ½ inch above the line *t i* and make the apex of the hood the same distance above *u m* as the lower apex is below it. Then draw lines as shown which complete C and D.

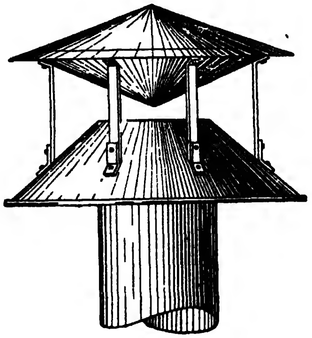


Fig. 39.

Now with *c* as a center and radii equal to *c e* and *c d* draw the quarter circles *e f* and *d h* respectively, which represent the one-

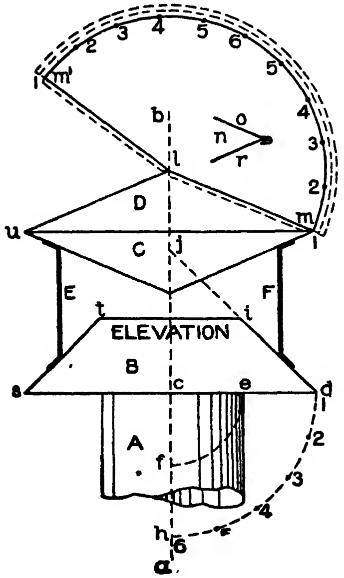


Fig. 38.

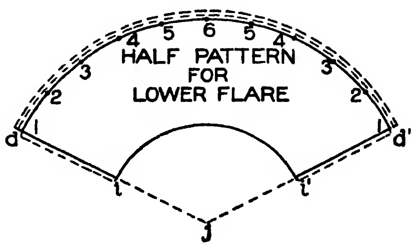


Fig. 40.

quarter pattern for the horizontal ring closing the bottom of the lower flare. For the pattern for the hood, use *l* as a center and *l m* as a radius. Now draw the arc *m m'*. Take the stretchout

of the quarter circle 1 to 6 on *d h*, and place twice this amount on *m m'* as shown from 1–6–1. Draw a line from 1 to *l*. Then *m'* 6 *m l*, will be the half pattern for the hood. As the deflector has the same bevel as the hood, the hood pattern will also answer for the deflector.

When seaming the hood and deflector together as shown at *n*, the hood *o* is double-seamed to the deflector at *r*, which allows the water to pass over; for this reason allow a double edge on the pattern for the hood as shown, while on the deflector but a single edge is required. Edges should also be allowed on *e d h f*.

For the pattern for the lower flare, extend the line *d i* until it intersects the center line at *j*. Then with radii equal to *j i* and *j d* and with *j* in Fig. 40 as center describe the arcs *i i'* and *d d'* On one side as *d* draw a line to *j* Then set off on the arc *d d*

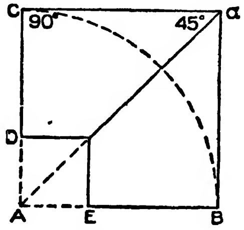


Fig. 41.

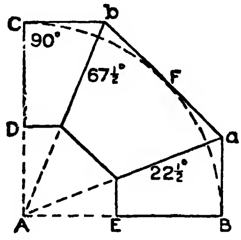


Fig. 42.

twice the number of spaces contained in *d h* in Fig. 38 as shown in Fig. 40. Draw a line from *d'* to i and allow edges for seaming. Then *d d' i' i* will be the half pattern for the lower flare.

The braces or supports E and F, Fig. 38, are usually made of galvanized band iron bolted or riveted to hood and pipe. The hood D must be water tight. or the water will leak into the deflector, from which it will drip from the apex inside the building.

Elbows. There is no other article in the sheet-metal worker's line, of which there are more made in practice than elbows. On this account rules will be given for constructing the rise of the miter line in elbows of any size or diameter, also for elbows whose sections are either oval, square or round, including tapering elbows Before taking up the method of obtaining the patterns, the rule will be given for obtaining the rise of the miter line for any size

or number of pieces. No matter how many pieces an elbow has, they join together and form an angle of 90°. Thus when we speak of a two-pieced, three-pieced, four, five or six-pieced elbow, we understand that the right-angled elbow is made up of that number of pieces. Thus in Fig. 41 is shown a two-pieced elbow placed in the quadrant C B, which equals 90° and makes C A B a right angle. From A draw the miter line A *a* at an angle of 45° to the base line A B. Then parallel to A B and A C and tangent to the quadrant at C and B draw lines to intersect the miter line, as shown. Knowing the diameter of the pipe as C D or E B draw lines parallel to the arms of the pipe, as shown. Then C B E D will be a two-pieced elbow, whose miter line is an angle of 45°.

In a similar manner draw the quadrant B C, Fig. 42, in which it is desired to draw a three-pieced elbow. Now follow this simple

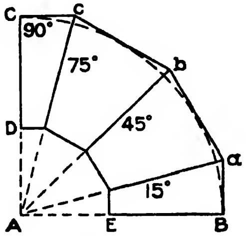


Fig. 43.

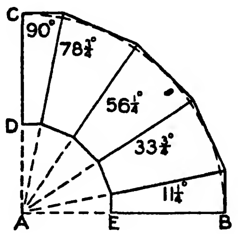


Fig. 44.

rule, which is applicable for any number of pieces: Let the top piece of the elbow represent 1, also the lower piece 1, and for every piece between the top and bottom add 2. Thus in a three-pieced elbow:

Top piece equals	1
Bottom piece equals	1
One piece between	2
Total equals	4

Now divide the quadrant of 90° by 4 which leaves 22½°. As one piece equals 22½°, draw the lower miter line A *a* at that angle to the base line A B. Then as the middle piece represents two by the above rule and equals 45°, add 45 to 22½ and draw the second miter line A *b*, at an angle of 67½° to the base line A B. Now tangent to the quadrant at C and B draw the vertical and

horizontal lines shown, until they intersect the miter lines, from which intersections draw the middle line, which will be tangent to the quadrant at F. C D and B E show the diameters of the pipe, which are drawn parallel to the lines of the elbow shown.

Fig. 43 shows a four-pieced elbow, to which the same rule is applied. Thus the top and bottom piece equals 2 and the two middle pieces equal 4; total 6. Now divide the quadrant of 90° by 6. $\frac{90}{6} = 15$. Then the first miter line A a will equal 15°, the second A b 45°, the third A c 75°, and the vertical line A C 90°.

The last example is shown in Fig. 44, which shows a five-pieced elbow, in which the top and bottom pieces equal 2, the 3 middle pieces 6; total 8. Divide 90 by 8. $\frac{90}{8} = 11\frac{1}{4}$. Then the first miter line will equal $11\frac{1}{4}$°, the second $33\frac{3}{4}$°, the third $56\frac{1}{4}$°, and the fourth $78\frac{3}{4}$°. By using this method an elbow having any number of pieces may be laid out. When drawing these miter lines it is well to use the protractor shown in Fig. 45, which illustrates how to lay out a three-pieced elbow. From the center point A of the protractor draw lines through $22\frac{1}{2}$°, and $67\frac{1}{2}$°. Now set

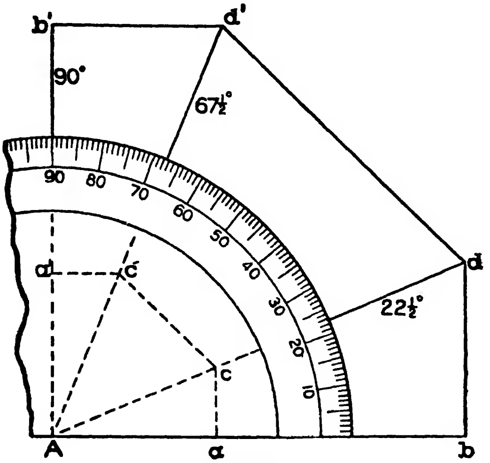


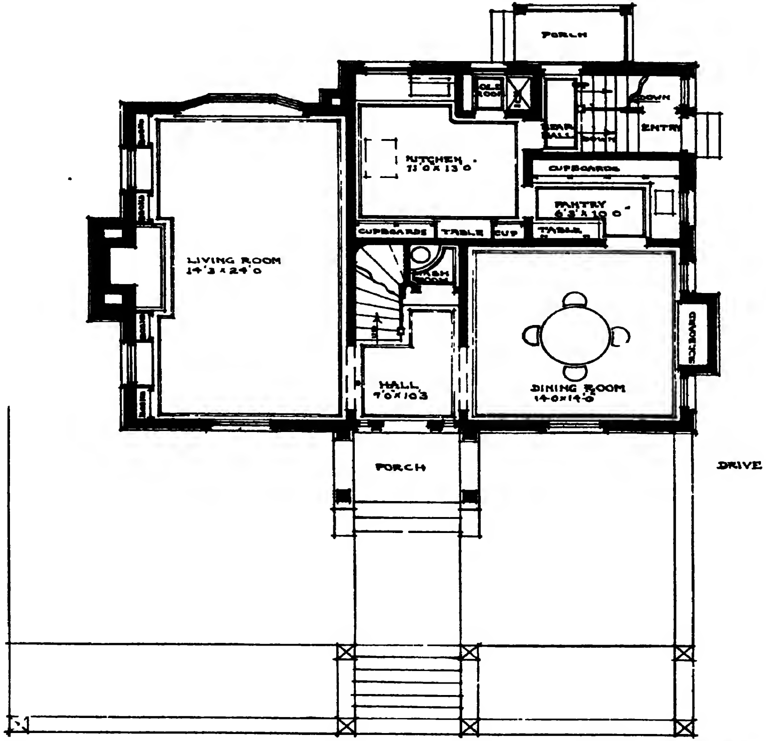
Fig. 45.

off A a, and the diameter of the pipe a b. Draw vertical lines from a and b to the miter line at c and d. Lay off similar distances from A to a' to b' and draw horizontal lines intersecting the $67\frac{1}{2}$° miter line at c' and d'. Then draw the lines d d' and c c' to complete the elbow. In practice, however, it is not necessary to draw out the entire view of the elbow; all that is required is the first miter line, as will be explained in the following problems.

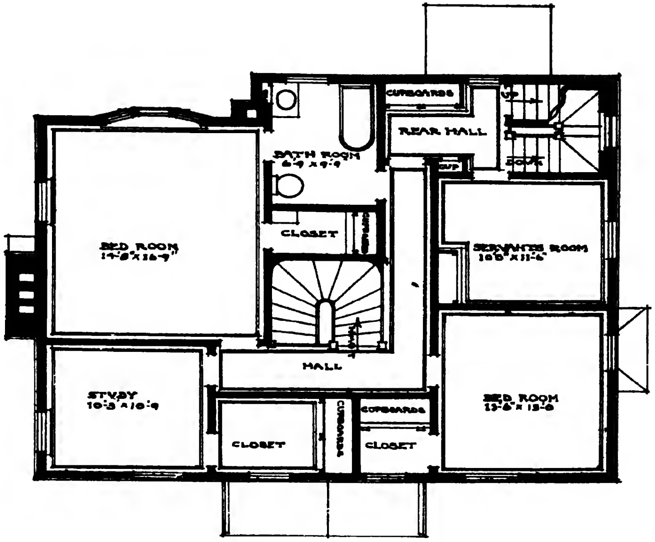
RESIDENCE OF MR. E. S. MEYER, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

Materials: First Story of Brick; Second Story and Roofs of Shingles. Built in 1904. Cost, $7,000. **For Plans, See Opposite Page.**



-FIRST-FLOOR-PLAN



SECOND FLOOR PLAN

FIRST AND SECOND STORY PLANS OF RESIDENCE OF MR. E. S. MEYER, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

EXERCISES FOR PRACTICE.

1. Make the diameter of the pipe $1\frac{3}{4}$ inches and the distances from A to E $1\frac{1}{2}$ inches in Figs. 41 to 44 inclusive.

To obtain the pattern for any elbow, using but the first miter

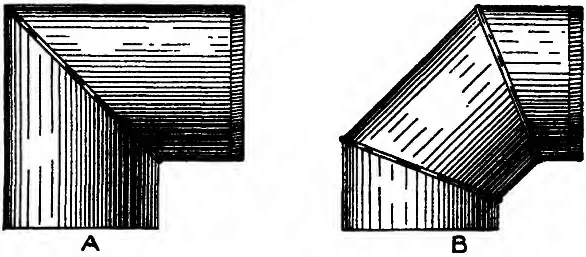


Fig. 46.

line, proceed as follows: In Fig. 46 let A and B represent respectively a two- and three-pieced elbow for which patterns are desired. First draw a section of the elbow as shown at A in Fig. 47 which

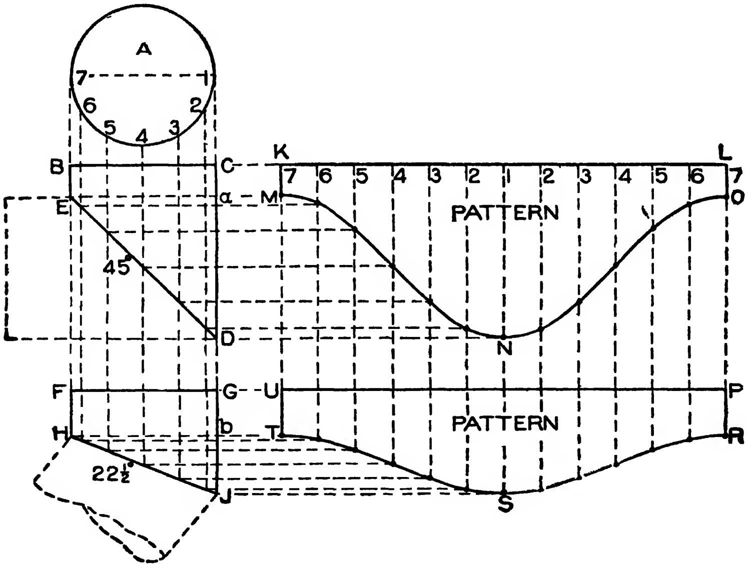


Fig. 47.

is a circle 3 inches in diameter; divide the lower half into equal spaces and number the points of division 1 to 7. Now follow the rule previously given: The top and bottom piece equals 2; then

for a two-pieced elbow divide 90 by 2. In its proper position below the section A draw B C D E making E D 45°. From the various points of intersection in A drop vertical lines intersecting E D as

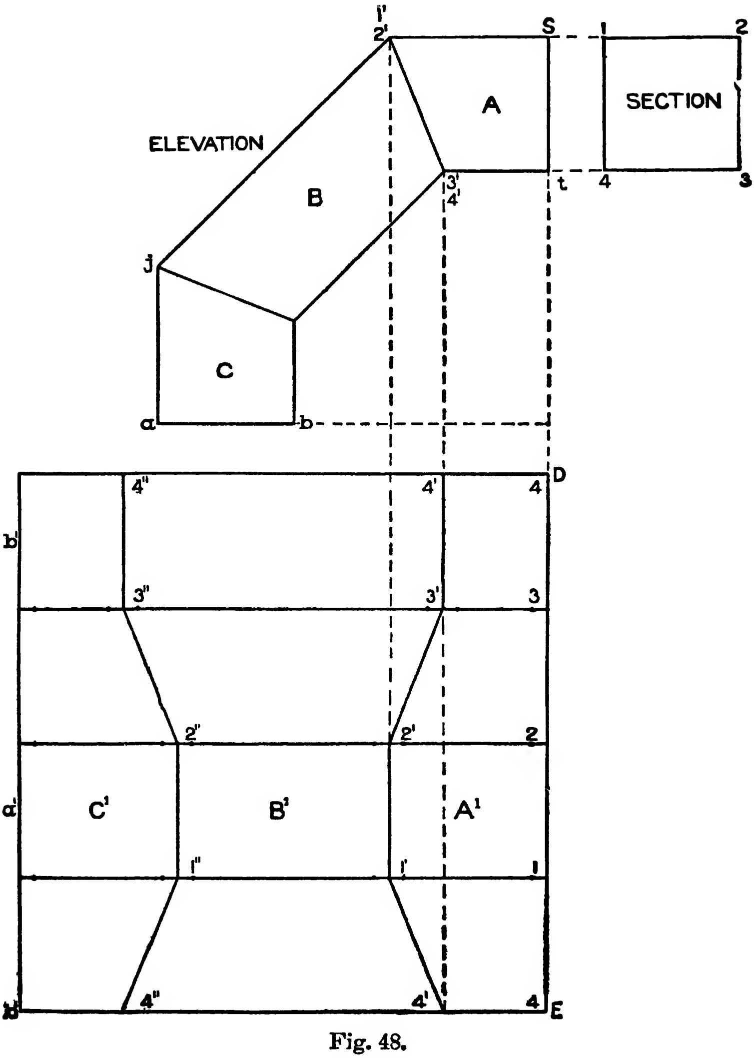


Fig. 48.

shown. In line with B C draw K L upon which place twice the number of spaces contained in the section A as shown by similar figures on K L; from these points drop perpendiculars to intersect

with lines drawn from similar intersections on E D, parallel to K L. Trace a line through points shown; then K L O N M will be the pattern. To this laps must be allowed for seaming.

Now to obtain the pattern for a three-pieced elbow, follow the rule Top and bottom pieces equal 2, one middle piece equals 2; total 4. $\frac{90}{4} = 22\frac{1}{2}$. Therefore in line with the section A below the two-pieced elbow draw F G J H, making H J at an angle of $22\frac{1}{2}°$ to the line H *b*. Proceed as above using the same stretchout lines; then U P R S T will be the desired pattern. It should be understood that when the protractor is used for obtaining the angle as shown in Fig. 45, the heights *a c* and *b* d measured from the horizontal line form the basis for obtaining the heights of the middle pieces, inasmuch as they represent one-half the distance; for that reason the middle pieces count 2 when using the rule. Therefore, the distances F H and G J (Fig. 47), represent one-half of the center piece and U T S R P one-half the pattern for the center piece of a three-pieced elbow.

Fig. 48 shows how the patterns are laid into one another, to prevent waste of metal when cutting. In this example we have a three-pieced elbow whose section is 2 $\times$ 2 inches. It is to be laid out in a quadrant whose radius is 5 inches. Use the same principles for square section as for round; number the corners of the section 1 to 4. In line with S *t* draw D E upon which place the stretchout of the square section as shown by similar numbers on D E; from which draw horizontal lines which intersect lines drawn parallel to D E from the intersections 1′ 2′ and 3′ 4′ in A in elevation, thus obtaining similar points in the pattern. Then A^1 will be the pattern for A in elevation. For the pattern f r B simply take the distance from 2′ to *j* and place it on the line 4 4′ extended in the pattern on either side as shown by 4′ 4″ on both sides. Now reverse the cut 4′ 2′ 4′ and obtain 4″ 2″ 4″. By measurement it will be found that 4′ 4″ is twice the length of 2′ 2 as explained in connection with Figs. 45 and 47. Make the distance from 1″ to *a′* the same as *j* to *a* in C and draw the vertical line *b′ b′* intersecting the lines 4 4″ extended on both sides. Then A^1, B^1, and C^1 will be the patterns in one piece minus the edges for

seaming which must be allowed between these cuts; this would of course make the lengths b′ 4″, 4″ 4′ and 4′ 4 as much longer as the laps would necessitate.

This method of cutting elbows in one piece, from one square is applicable to either round, oval or square sections.

In Figs. 49 and 50 are shown three-pieced elbows such as are

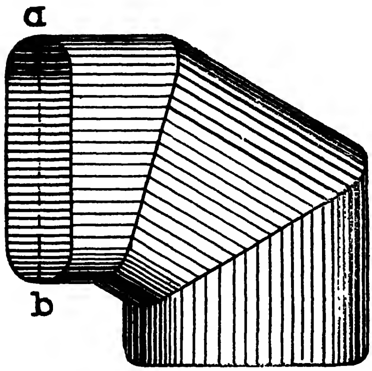


Fig. 49.

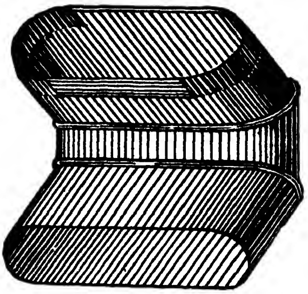


Fig. 50.

used in furnace-pipe work and are usually made from bright tin. Note the difference in the position of the sections of the two elbows. In Fig. 49 *a b* is in a vertical position, while in Fig. 50 it is in a horizontal position. In obtaining the patterns the same rule is employed as in previous problems, care being taken when developing the patterns for Fig. 49 that the section be placed as in Fig. 51 at A; and when developing the patterns for Fig. 50, that the section be placed as shown at A in Fig. 52.

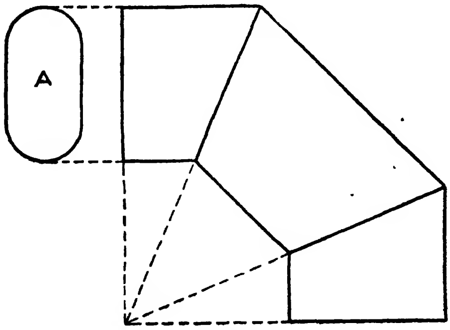


Fig. 51.

Fig. 53 shows a tapering two-pieced elbow, round in section. The method here shown is short and while not strictly accurate, gives good results. It has been shown in previous problems on Intersections and Developments that an oblique section through the opposite

sides of a cone is a true ellipse. Bearing this in mind it is evident that if the frustum of the cone H I O N, Fig. 54, were a solid and cut obliquely by the plane J K and the several parts placed side by side, both would present true ellipses of exactly the same size, and if the two parts were placed together again turning the upper piece half-way around as shown by J W M K, the edges

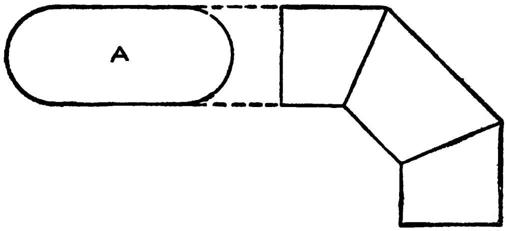


Fig. 52.

of the two pieces from J to K would exactly coincide. Taking advantage of this fact, it is necessary only to ascertain the angle of the line J K, to produce the required angle, between the two pieces of the elbow, both of which have an equal flare. The angle of the miter line, or the line which cuts the cone in two parts, must be found accurately so that when joined together an elbow will be formed having the desired angle on the line of its axis.

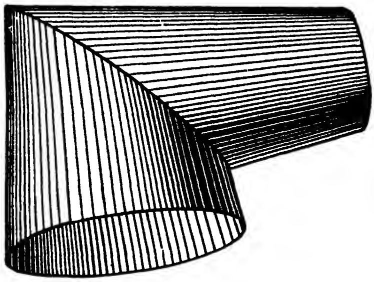


Fig. 53.

Therefore draw any vertical line as A B. With C as a center describe the plan of the desired diameter as shown by E D F B. At right angles to A B draw the bottom line of the elbow H I equal to E F, or in this case, 3 inches. Measuring from the line H I on the line A B the height of the frustum is 5 inches. Through X′ draw the upper diameter O N, $1\frac{1}{2}$ inches. Extend the contour lines of the frustum until they intersect the center line at L. Divide the half plan E D F into a number of equal parts as shown; from these points erect lines intersecting the base line H I from which draw lines to the apex L. As the elbow is to be in two pieces, and the axis at right angles, draw the angle T R S,

bisect it at U and draw the line R V. No matter what the angle of the elbow, use this method. Now establish the point J at some convenient point on the cone, and from J, parallel to R V, draw the miter line J K intersecting the radial lines drawn through the cone; from these points and at right angles to the center line A B draw lines intersecting the side of the cone J H from 1 to 7. If it is

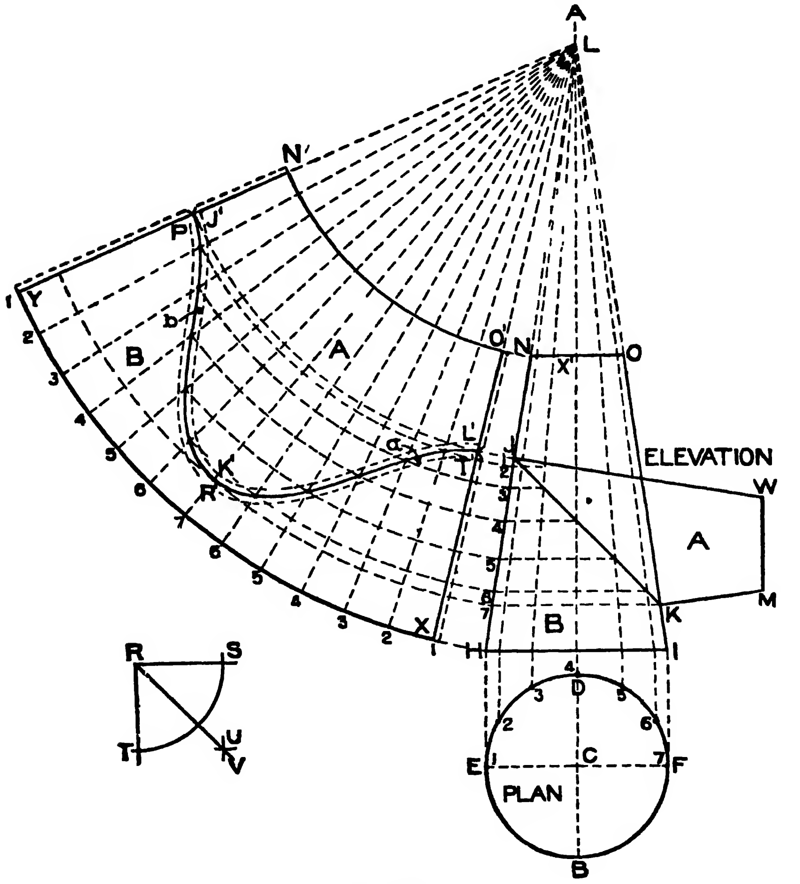


Fig. 54.

desired to know how the side of the tapering elbow would look, take a tracing of N O K J, reverse it and place it as shown by J W M K.

For the pattern proceed as follows: With L as a center and L H as a radius describe the arc 1 1. Starting from 1 set off on

this arc twice the stretchout of 1 4 7 in plan, as shown by similar figures on 1 1, from which draw radial lines to the apex L. Again using L as center with radii equal to L N, L 1, L 2 to L 7, draw arcs as shown intersecting radial lines having similar numbers. Through these intersections draw the line J′ L′. Then O′ N′ J′ K′ L′ or A will be the pattern for the upper arm (A) in elevation, and P′ R′ T′ X Y or B the pattern for the lower arm (B) in elevation.

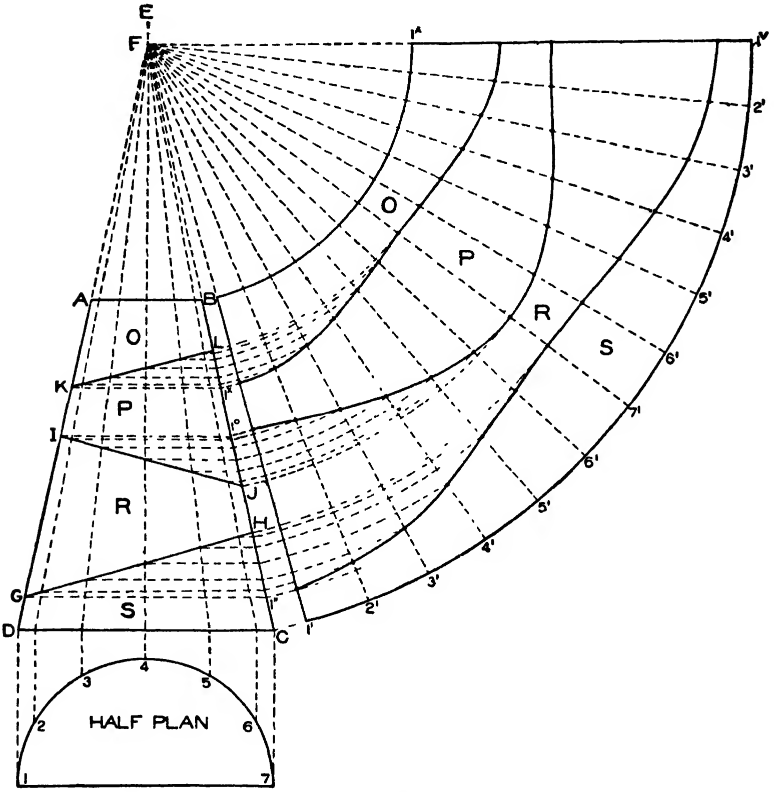


Fig. 55.

The pattern should be developed full size in practice and then pricked from the paper on to the sheet metal, drawing the two patterns as far apart as to admit allowing an edge to A at *a*; also an edge at *b* to B for seaming.

When a pattern is to contain more than two pieces the method of constructing the miter lines in the elevation of the cone is

slightly different as shown in Fig. 55. Assume the bottom to be 3 inches in diameter and the top $1\frac{1}{4}$ inches. Let the vertical height be 4 inches. In this problem, as in the preceding, the various pieces necessary to form the elbow are cut from one cone whose dimensions must be determined from the dimensions of the required elbow. The first step is to determine the miter lines, which can be done the same as if regular pieced elbows were being developed. As the elbow is to consist of four pieces in 90°, follow the rule given in connection with elbow drafting. The top and bottom piece equal 2; the two middle pieces equal 4; total 6. $\frac{90}{6} = 15$ Lay off A B C D according to the dimensions given, and draw the half plan below D C; divide it into equal parts as shown. From the points of division erect perpendiculars intersecting D C, from which draw lines meeting the center line E 4 at F.

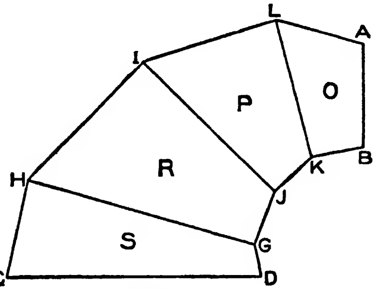


Fig. 56.

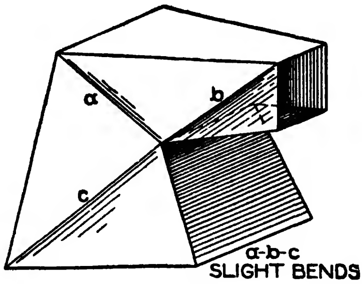


Fig. 57.

We assume that the amount of rise and projection of the elbow are not specified, excepting that the lines of axis will be at right angles. Knowing the angle of the miter line, it becomes a matter of judgment upon the part of the pattern draftsman, what length shall be given to each of the pieces composing the elbow. Therefore establish the points G, I and K, making D G, G I, I K and K A $\frac{1}{2}$, $1\frac{7}{8}$, $\frac{3}{4}$ and 1 inch respectively. From G, I and K draw the horizontal lines G 1″, I 1° and K 1^{x}. To each of these lines draw the lines G H, I J and K L respectively at an angle of 15° intersecting the radial lines in the cone as shown. From these intersections draw horizontal lines cutting the side of the cone. Then using F as a center, obtain the various patterns O, P, R and S in the manner already explained.

In Fig. 56 is shown a side view of the elbow, resulting from preceding operations; while it can be drawn from dimensions obtained in Fig. 55, it would be impossible to draw it without first having these dimensions.

In Fig. 57 is shown a perspective view of a tapering square elbow of square section in two pieces. This elbow may have any given taper. This problem will be developed by triangulation and parallel lines; it is an interesting study in projections as well as in developments. First draw the elevation of the elbow in Fig. 58 making 1–6 equal to $3\frac{1}{2}$ inches, the vertical height 1–2, $4\frac{1}{2}$ inches, and 6–5, $2\frac{1}{2}$ inches; the projection between 1 and 2 should be $\frac{5}{8}$ inch and between 5 and 6, $\frac{3}{8}$ inch. Make the horizontal distance

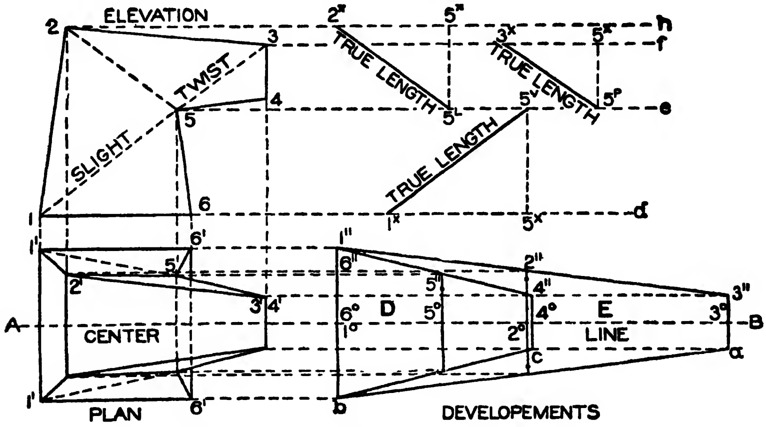


Fig. 58.

from 5 to 4, 2 inches, and the rise at 4 from the horizontal line $\frac{1}{4}$ inch, and the vertical distance from 4 to 3, $1\frac{1}{4}$ inches. Then draw a line from 3 to 2 to complete the elevation.

In its proper position below the line 1–6, draw the plan on that line, as shown by 1′ 1′ 6′ 6′. Through this line draw the center line A B. As the elbow should have a true taper from 1 to 3 and from 4 to 6, we may develop the patterns for the top and bottom pieces first and then from these construct the plan. Therefore, take the distances from 1 to 2 to 3 and from 4 to 5 to 6 in elevation and place them on the line A B in plan as shown respectively from 1° to 2° to 3° and from 4° to 5° to 6°; through these points draw vertical lines as shown. While the full developments

E and D are shown we shall deal with but one-half in the explanation which follows. As the elbow is to have the same taper on either side, take the half distance of the bottom of the elbow 1–6 and place it as shown from 1°–6° to 1″–6″, and the half width of the top of the elbow 3–4 and place it as shown from 3° to 3″ and 4° to 4″. Then draw lines from 3″ to 1″ intersecting the bend 2° at 2″, and a line from 4″ to 6″ intersecting the bend 5° at 5″. Trace these points on the opposite side of the line A B. Then 1″ 3″ *a b* will be the pattern for the top of the elbow and 6″ 4″ *c b* the pattern for the bottom. From these various points of intersection draw horizontal lines to the plan, and intersect them by lines drawn from similarly numbered points in the elevation at right angles to A B in plan. Draw lines through the points thus obtained in plan as shown by 1′, 2′, 3′, 4′, 5′ and 6′ which will represent the half plan view. For the completed plan, trace these lines opposite the line A B as shown. It will be noticed that the line 3–4 in elevation is perpendicular as shown by 3′ 4′ in plan while the points 2′ and 5′ project from it, showing that the piece 2–3–4–5 in elevation must be slightly twisted along the line 5-3 when forming the elbow. Similarly slight bends will be required along the lines 1–5 and 5–2.

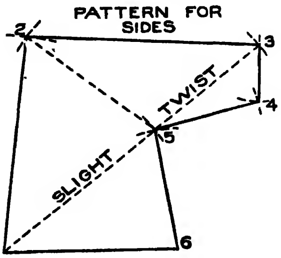


Fig. 59.

It will now be necessary to obtain the true lengths or a diagram of triangles on the lines 1–5, 5–2 and 5–3. Connect similar numbers in plan as shown from 1′ to 5′, 5′ to 2′ and 5′ to 3′, the last two lines being already shown. From similar points in elevation draw horizontal lines as shown by 2–*h*, 3–*f*, 5–*e* and 6-*d*. Take the distances from 1′ to 5′, 5′ to 2′ and 5′ to 3′ in plan and place them on one of the lines having a similar number in elevation, as shown respectively by 1^x 5^x, 5^x 2^x and 5^x 3^x. From the points marked 5^x draw vertical lines intersecting the horizontal line drawn from 5 at 5^v, 5^L and 5^p respectively. Now draw the true lengths 1^x 5^v, 2^x 5^L, and 3^x 5^p. For the pattern draw any line as 1–6 in Fig. 59 equal to 1–6 in Fig. 58. Now with 6″ 5″ in D as a radius and 6 in Fig. 59 as a center, describe the arc 5 which is intersected by an arc struck from 1 as a center and the true length

$1^x 5^v$ in Fig. 58 as radius. Then using the true length $5^L 2^x$ as radius and 5 in Fig. 59 as center, describe the arc 2, which is intersected by an arc struck from 1 as center and 1″ 2″ in E in Fig. 58 as radius. Using the true length $5^p 3^x$ as radius and 5 in Fig. 59 as center, describe the arc 3, and intersect it by an arc struck from 2 as center and 2″ 3″ in E in Fig. 58 as a radius. Now with 5″ 4″ in D as a radius and 5 in Fig. 59 as a center, describe tht arc 4, and intersect it by an arc struck from 3 as center and 3–4 in the elevation in Fig. 58 as a radius. Draw lines from point to point in Fig. 59 to complete the pattern. Laps should be allowed on all patterns, for seaming. Slight bends will take place as shown on the pattern, also as is shown by *a b* and *c* in Fig. 57. If the joint is to be on the line 2–5 in elevation in Fig. 58, the necessary pieces can be joined together.

In Fig. 60 is shown a perspective view of a five-piece tapering elbow, having a round base and an elliptical top. This form is generally known as a *ship ventilator.* The principles shown in this problem are applicable to any form or shape no matter what the respective profiles may be at the base or top. The first step is to draw a correct side view of the elbow as shown in Fig. 61. The outline A B C D E F can be drawn at pleasure, but for practice, dimensions are given. First draw the vertical line A F equal to $4\frac{1}{2}$ inches. On the same line extend measure down $1\frac{1}{4}$ inches to

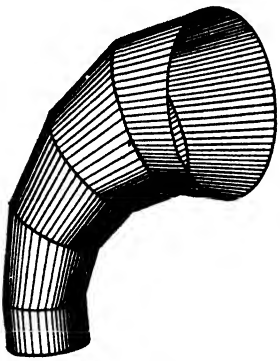


Fig. 60.

f and draw the horizontal line H B. From *f* set off a distance of $1\frac{1}{4}$ inches at G, and using G as a center and G F as a radius describe the arc F E intersecting H B at E, from which draw the vertical line E D equal to 1 inch. Draw D C equal to $1\frac{3}{4}$ inches, then draw C B. From B lay off $5\frac{3}{4}$ inches, and using this point (H) as a center and H B as a radius describe the arc B A. The portion shown B E D C is a straight piece of pipe whose section is shown by I J K L. Now divide the two arcs B A and E F into the same number of parts that the elbow is to have pieces (in this case four) and draw the lines of joint or miter lines as shown by U V, etc.

Bisect each one of the joint lines and obtain the points *a b c d* and *e*. Then A B C D E F will be the side view.

The patterns will be developed by triangulation, but before this can be done, true sections must be obtained on all of the lines in side elevation. The true sections on the lines B E and C D are shown by I J K L. The length of the sections are shown by the joint lines, but the width must be obtained from a front outline of the elbow, which is constructed as follows: In its proper relation to the side elevation, draw the center line M R upon which draw

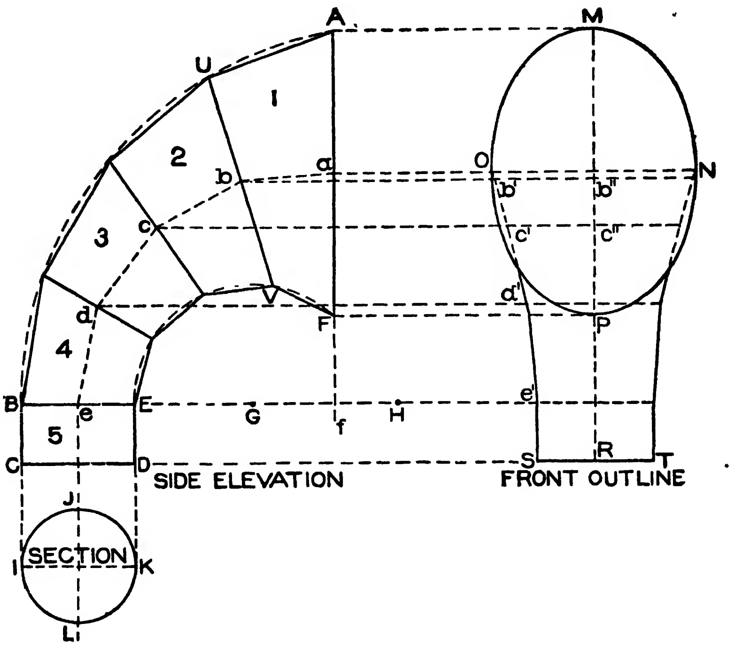


Fig. 61.

the ellipse M N O P (by methods already given in Mechanical Drawing) which represents the section on A F in side. Take half the diameter I K in section and place it on either side of the center line M R as R T or R S. Then draw the outline O S and T N in a convenient location. While this line is drawn at will, it should be understood that when once drawn, it becomes a fixed line. Now from the various intersections *a b c d* and *e* in the side elevation, draw lines through and intersecting the front outline as shown on

one side by O, b', c', d' and e'. Then these distances will represent the widths of the sections shown by similar letters in side. For example, the method will be shown for obtaining the true section on U V, and the pattern for piece 1 in side elevation. To avoid a confusion of lines take a tracing of A F V U and place it as shown by 1, 13, 12, O in Fig. 62. On 1–13 place the half profile M N P of Fig. 61. Bisect O–12 in Fig. 62 and obtain the point 6; at a right angle to O–12 from 6 draw the line 6 6′ equal to b' b'' in front outline in Fig. 61. Then through the three points O, 6′ and 12 in Fig. 62, draw the semi-ellipse, which will represent the half section on U V. The other

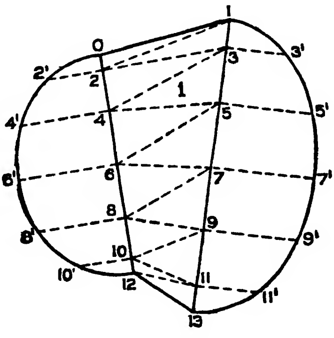


Fig. 62.

sections on the joint lines in side elevation are obtained in the same manner.

If the sections were required for piece 2 in side it would be necessary to use only O 6′ 12 in Fig. 62 and place it on U V in Fig. 61, and on a perpendicular line erected from c, place the width c' c'' shown in front and through the three points obtained again draw the semi-elliptical profile or section. Now divide the two half sections (Fig. 62) into equal parts as shown by the small figures, from which at right angles to 1–13 and O–12 draw lines intersecting these base lines from 1–13. Connect opposite points as 1 to 2 to 3 to 4 to 5, etc., to 12. Then these lines will represent

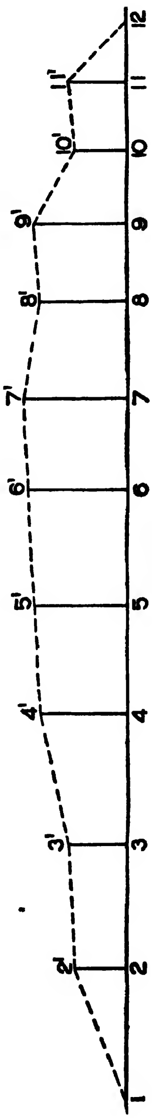


Fig. 63.

the bases of sections whose altitudes are equal to the heights in the half section. For these heights proceed as follows:

Take the various lengths from 1 to 2, 2 to 3, 3 to 4, 4 to 5, etc., to 11 to 12 and place them on the horizontal line in Fig. 63 as shown by similar figures; from these points erect vertical lines equal in height to similar figures, in the half section in Fig. 62 as shown by similar figures in Fig. 63. For example: Take the distance from 7 to 8 in Fig. 62 and place it as shown from 7 to 8 in Fig. 63 and erect vertical lines 7–7′, and 8–8′ equal to 7–7′ and 8–8′ in Fig. 62. Draw a line from 7′ to 8′ in Fig. 63 which is the true length on 7–8 in Fig. 62. For the pattern take the distance of 1–O and place it as shown by 1–O in Fig. 64. Now using O as a center and O 2′ in Fig. 62 as a radius, describe the arc 2 in Fig. 64

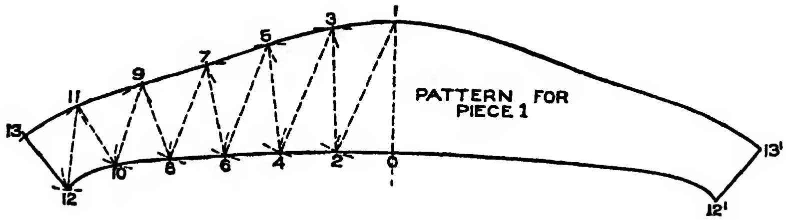


Fig. 64.

and intersect it by an arc struck from 1 as a center with 1–2′ in Fig. 63 as a radius. Now with 1–3′ in Fig. 62 as a radius and 1 in Fig. 64 as a center, describe the arc 3, and intersect it by an arc struck from 2 as center and 2′–3′ in Fig. 63 as a radius. Proceed thus, using alternately as radii, first the divisions in O–6′–12 in Fig. 62, then the proper line in Fig. 63, the divisions in 1-7′-13 in Fig. 62 and again the proper line in Fig. 63, until the line 12–13 in Fig. 64 is obtained, which equals 12–13 in Fig. 62. In this manner all of the sections are obtained, to which laps must be allowed for wiring and seaming.

TABLES.

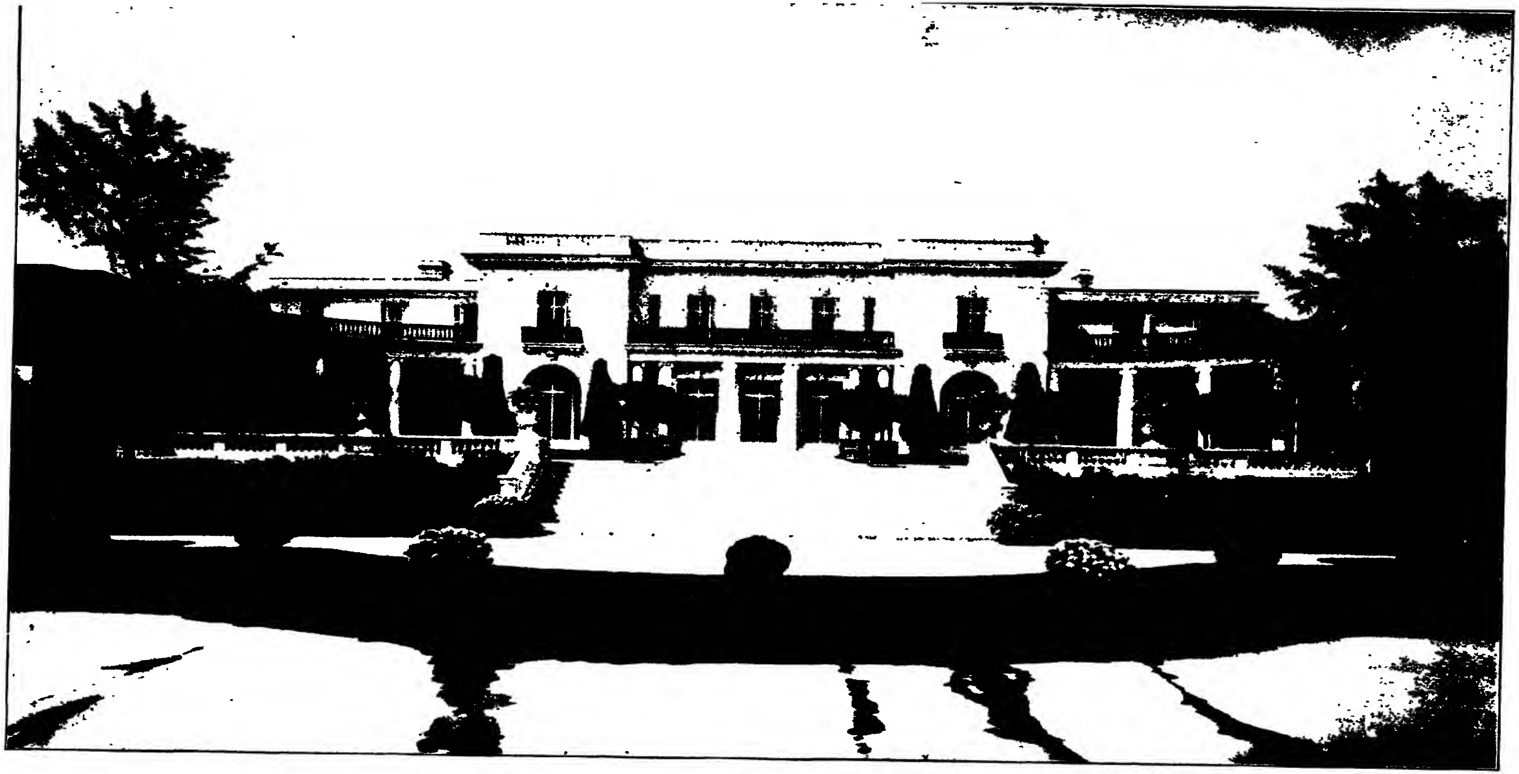
The following tables will be found convenient for the Sheet-Metal Worker:

WEIGHT OF A SQUARE FOOT OF CAST AND WROUGHT IRON, COPPER, LEAD, BRASS AND ZINC.

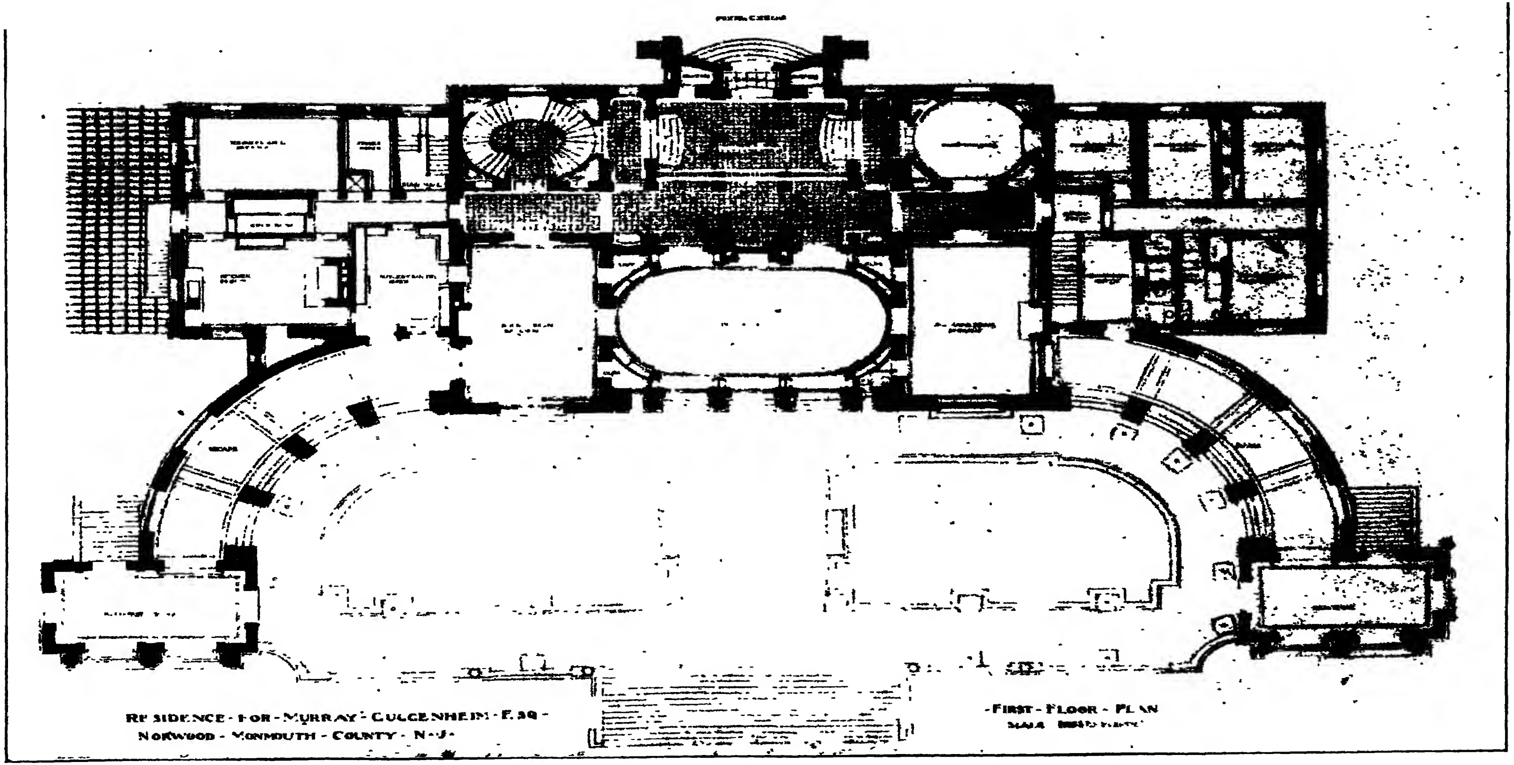
FROM $\frac{1}{16}$ INCH TO ONE INCH IN THICKNESS.

THICKNESS.	CAST IRON.	WROUGHT IRON.	COPPER.	LEAD.	BRASS.	ZINC.
Inch.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1–16	2.346	2.517	2.89	3.691	2.675	2.34
1–8	4.693	5.035	5.781	7.382	5.35	4.68
3–16	7.039	7.552	8.672	11.074	8.025	7.02
1–4	9.386	10.07	11.562	14.765	10.7	9.36
5–16	11.733	12 588	14.453	18.456	13.375	11.7
3–8	14.079	15.106	17.344	22.148	16.05	14.04
7–16	16.426	17.623	20.234	25.839	18.725	16.34
1–2	18.773	20.141	23.125	29.53	21.4	18.72
9–16	21.119	22.659	26.016	33.222	24.075	
5–8	23.466	25.176	28.906	36.923	26.75	
11–16	25.812	27.694	31.797	40.604	29.425	
3–4	28.159	30.211	34.688	44.296	32.1	
13–16	30.505	32.729	37.578	47.987		
7–8	32.852	35.247	40.469	51.678		
15–16	35.199	37.764	43.359	55.37		
1	37.545	40.282	46.25	59.061		

NOTE.—The wrought iron and the copper weights are those of hard-rolled plates.

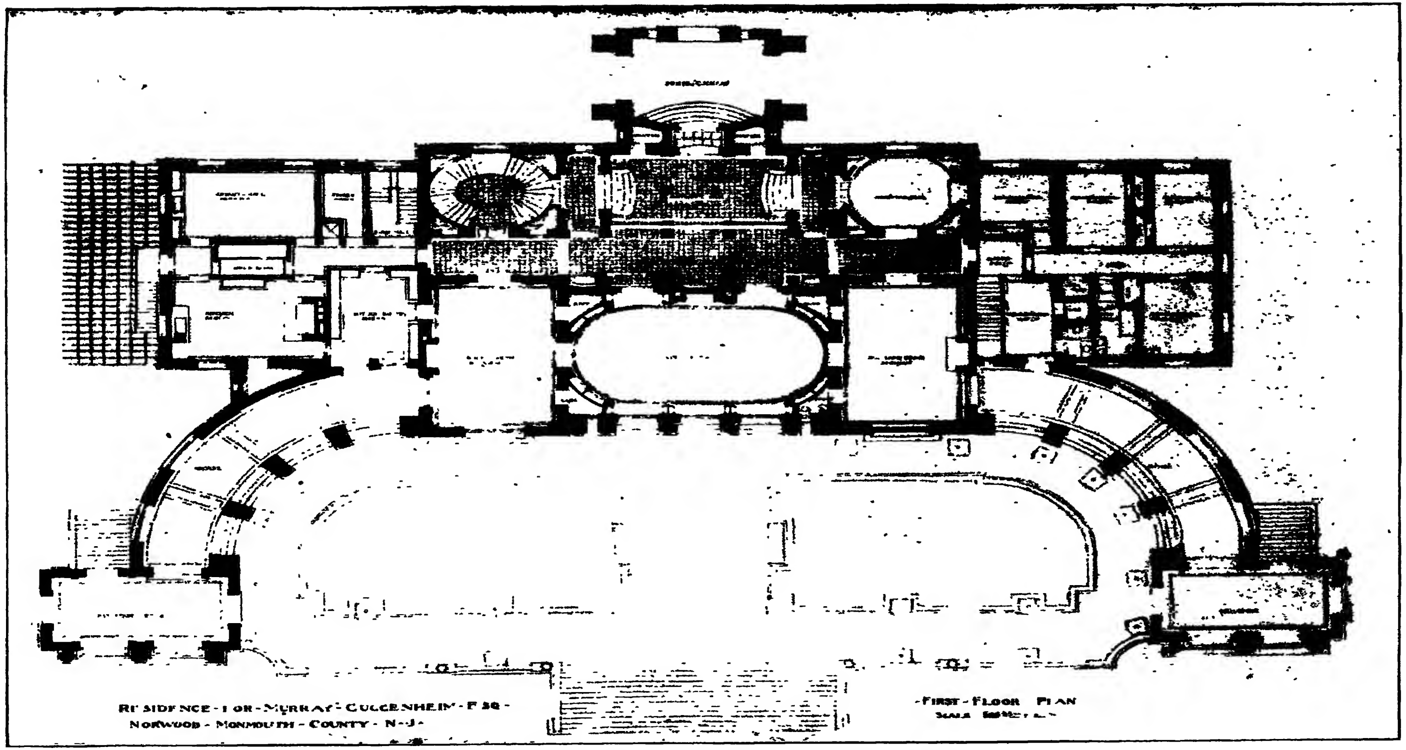


RESIDENCE FOR MURRAY GUGGENHEIM, ESQ., NORWOOD, N. J.
Carrère & Hastings, Architects, New York.



FIRST-FLOOR PLAN OF RESIDENCE FOR MURRAY GUGGENHEIM, ESQ., NORWOOD, N. J.
Carrère & Hastings, Architects, New York.

RESIDENCE FOR MURRAY GUGGENHEIM, ESQ., NORWOOD, N. J.
Carrère & Hastings, Architects, New York.
Plan Shown on Opposite Page



FIRST-FLOOR PLAN OF RESIDENCE FOR MURRAY GUGGENHEIM, ESQ., NORWOOD, N. J.
Carrère & Hastings, Architects, New York.
For Exterior View, See Opposite Page.

SHEET COPPER.

Official table adopted by the Association of Copper Manufacturers of the United States. Rolled copper has specific gravity of 8.93. One cubic foot weighs 558.125 pounds. One square foot, one inch thick, weighs 46.51 pounds.

Stubs' Gauge, (nearest number).	Thickness in decimal parts of an inch.	Ounces per sq. ft.	Sheets 14"x48" Weight in pounds.	Sheets 24"x48" Weight in pounds.	Sheets 30"x60" Weight in pounds.	Sheets 36"x72" Weight in pounds.	Sheets 48"x72" Weight in pounds.
35	.00537	4	1.16	2	3.12	4.50	6
33	.00806	6	1.75	3	4.68	6.75	9
31	.0107	8	2.33	4	6.25	9	12
29	.0134	10	2.91	5	7.81	11.25	15
27	.0161	12	3.50	6	9.37	13.50	18
26	.0188	14	4.08	7	10.93	15.75	21
24	.0215	16	4.66	8	12.50	18	24
23	.0242	18	5.25	9	14.06	20.25	27
22	.0269	20	5.83	10	15.62	22.50	30
21	.0322	24	7	12	18.75	27	36
19	.0430	32	9.33	16	25	36	48
18	.0538	40	11.66	20	31.25	45	60
16	.0645	48	14	24	37.50	54	72
15	.0754	56	16.33	28	43.75	63	84
14	.0860	64	18.66	32	50	72	96
13	.095	70	....	35	55	79	105
12	.109	81	....	40½	63	91	122
11	.120	89	....	44½	70	100	134
10	.134	100	....	50	78	112	150
9	.148	110	....	55	86	124	165
8	.165	123	....	61	96	138	184
7	.180	134	....	67	105	151	201
6	.203	151	....	75½	118	170	227
5	.220	164	....	82	128	184	246
4	.238	177	....	88½	138	199	266
3	.259	193	....	96	151	217	289
2	.284	211	....	105½	165	238	317
1	.300	223	....	111½	174	251	335
0	.340	253	....	126½	198	285	380

SHEET ZINC.

Numbers		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Weight per sq. foot		.30	.37	.45	.52	.60	.67	.75	.90	1.05	1.20	1.35	1.50	1.68	1.87	2.06	2.25	2.62	3.00	3.37
Approximate thickness in inches		.008	.010	.012	.014	.016	.018	.020	.024	.028	.032	.036	.040	.045	.050	.055	.060	.070	.080	.090
Size of sheet.	Sq. ft. per sheet.	APPROXIMATE WEIGHT PER SHEET.																		
24 x 84 in.	14.	4.2	5.2	6.3	7.3	8.4	9.4	10.5	12.6	14.7	16.8	18.9	21.	23.5	26.2	28.9	31.5	36.7	42.	47.2
26 x 84	15.2	4.6	5.6	6.9	7.9	9.1	10.2	11.4	13.7	16.	18.3	20.5	22.8	25.6	28.4	31.3	34.2	39.9	45.6	51.2
28 x 84	16.3	4.9	6.	7.4	8.5	9.8	10.9	12.2	14.7	17.1	19.6	22.	24.5	27.4	30.5	33.6	36.7	42.7	48.9	54.9
30 x 84	17.5	5.3	6.5	7.9	9.1	10.5	11.8	13.2	15.8	18.4	21.	23.6	26.2	29.4	32.8	36.1	39.4	45.8	52.5	59.
32 x 84	18.7	5.6	6.9	8.4	9.7	11.2	12.6	14.1	16.9	19.7	22.5	25.3	32.8	31.4	35.	38.5	42.	49.	56.1	63.
34 x 84	19.9	6.0	7.4	9.	10.4	12.	13.4	15.	18.	20.9	23.9	26.9	29.9	33.4	37.2	41.	44.8	52.2	59.7	67.
36 x 84	21.	6.3	7.8	9.5	10.9	12.6	14.1	15.8	18.9	22.	25.2	28.4	31.5	35.3	39.3	43.3	47.2	55.	63.	70.8
36 x 96	24.	7.2	8.9	10.8	12.5	14.4	16.1	18.	21.6	25.2	28.8	32.4	36.	40.3	44.9	49.5	54.	62.8	72.	80.9
36 x 108	27.	8.1	10.	12.2	14.1	16.2	18.1	20.3	24.3	28.4	32.4	36.5	40.5	45.4	50.5	55.6	60.7	70.7	81.	91.
40 x 84	23.4	7.	8.7	10.6	12.2	14.1	15.7	17.6	21.	24.6	28.1	31.6	35.1	39.3	43.8	48.2	52.6	61.3	70.2	78.8
40 x 96	26.8	8.	9.9	12.1	14.	16.1	18.	20.1	24.1	28.1	32.2	36.2	40.2	45.	50.1	55.2	60.3	70.2	80.4	90.3
44 x 84	25.7	7.7	9.5	11.6	13.4	15.4	17.2	19.3	23.1	27.	30.8	34.7	38.6	43.2	48.1	53.	57.8	67.4	77.1	86.6
46 x 90	28.7	8.6	10.6	12.9	14.9	17.2	19.2	21.5	25.8	30.1	34.4	38.7	43.	48.2	53.7	59.1	64.6	75.2	86.1	96.7
48 x 84	28.	8.4	10.4	12.6	14.6	16.8	18.8	21.	25.2	29.4	33.6	37.8	42.	47.	52.4	57.7	63.	73.4	84.	94.4
48 x 96	32.	9.6	11.9	14.4	16.7	19.2	21.5	24.	28.8	33.6	38.4	43.2	48.	53.8	59.9	65.9	72.	83.9	96.	107.8
50 x 108	37.5	11.3	13.9	16.9	19.5	22.5	25.1	28.2	33.8	39.3	45.	50.7	56.3	63.	70.1	77.3	84.4	98.3	112.5	126.4
52 x 84	30.4	9.1	11.3	13.7	15.8	18.3	20.4	22.8	27.4	31.9	36.5	41.	45.6	51.	56.9	62.6	68.4	79.6	91.2	102.5

Casks average about 600 pounds each. No. 4 to No. 17. Boxes average about 500 pounds. No. 18 and heavier.

UNITED STATES STANDARD GAUGE FOR SHEET AND PLATE IRON AND STEEL

COPY [Public—No. 137]

An act establishing a standard gauge for sheet and plate iron and steel.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the purpose of securing uniformity the following is established as the only standard gauge for sheet and plate iron and steel in the United States of America, namely:

Number of Gauge	THICKNESS		WEIGHT		Number of Gauge
	Approximate thickness in fractions of an inch	Approximate thickness in decimal parts of an inch	Weight per square foot in OUNCES avoirdupois	Weight per square foot in POUNDS avoirdupois	
0000000	1-2	.5	320	20.	0000000
000000	15-32	.46875	300	18.75	000000
00000	7-16	.4375	280	17.5	00000
0000	13-32	.40625	260	16.25	0000
000	3-8	.375	240	15.	000
00	11-32	.34375	220	13.75	00
0	5-16	.3125	200	12.5	0
1	9-32	.28125	180	11.25	1
2	17-64	.265625	170	10.625	2
3	1-4	.25	160	10.	3
4	15-64	.234375	150	9.375	4
5	7-32	.21875	140	8.75	5
6	13-64	.203125	130	8.125	6
7	3-16	.1875	120	7.5	7
8	11-64	.171875	110	6.875	8
9	5-32	.15625	100	6.25	9
10	9-64	.140625	90	5.625	10
11	1-8	.125	80	5.	11
12	7-64	.109375	70	4.375	12
13	3-32	.09375	60	3.75	13
14	5-64	.078125	50	3.125	14
15	9-128	.0703125	45	2.8125	15
16	1-16	.0625	40	2.5	16
17	9-160	.05625	36	2.25	17
18	1-20	.05	32	2.	18
19	7-160	.04375	28	1.75	19
20	3-80	.0375	24	1.5	20
21	11-320	.034375	22	1.375	21
22	1-32	.03125	20	1.25	22
23	9-320	.028125	18	1.125	23
24	1-40	.025	16	1.	24
25	7-320	.021875	14	.875	25
26	3-160	.01875	12	.75	26
27	11-640	.0171875	11	.6875	27
28	1-64	.015625	10	.625	28
29	9-640	.0140625	9	.5625	29
30	1-80	.0125	8	.5	30
31	7-640	.0109375	7	.4375	31
32	13-1280	.01015625	6½	.40625	32
33	3-320	.009375	6	.375	33
34	11-1280	.00859375	5½	.34375	34
35	5-640	.0078125	5	.3125	35
36	9-1280	.00703125	4½	.28125	36
37	17-2560	.0066406	4¼	.265625	37
38	1-160	.00625	4	.25	38

And on and after July first, eighteen hundred and ninety-three, the same and no other shall be used in determining duties and taxes levied by the United States of America on sheet and plate iron and steel. But this act shall not be construed to increase duties upon any articles which may be imported.

SEC. 2. That the Secretary of the Treasury is authorized and required to prepare suitable standards in accordance herewith.

SEC. 3. That in the practical use and application of the standard gauge hereby established a variation of two and one-half per cent either way may be allowed.

Approved, March 3, 1893.

WEIGHTS OF FLAT ROLLED IRON PER LINEAR FOOT.

Iron weighing 480 pounds per cubic foot.

Thickness in Inches.	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	12″
$\frac{1}{16}$	.208	.260	.313	.365	.417	.469	.521	.573	2.50
$\frac{1}{8}$	.417	.521	.625	.729	.833	.938	1.04	1.15	5.00
$\frac{3}{16}$	.625	.781	.938	1.09	1.25	1.41	1.56	1.72	7.50
$\frac{1}{4}$	.833	1.04	1.25	1.46	1.67	1.88	2.08	2.29	10.00
$\frac{5}{16}$	1.04	1.30	1.56	1.82	2.08	2.34	2.60	2.86	12.50
$\frac{3}{8}$	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	15.00
$\frac{7}{16}$	1.46	1.82	2.19	2.55	2.92	3.28	3.65	4.01	17.50
$\frac{1}{2}$	1.67	2.08	2.50	2.92	3.33	3.75	4.17	4.58	20.00
$\frac{9}{16}$	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	22.50
$\frac{5}{8}$	2.08	2.60	3.13	3.65	4.17	4.69	5.21	5.73	25.00
$\frac{11}{16}$	2.29	2.86	3.44	4.01	4.58	5.16	5.73	6.30	27.50
$\frac{3}{4}$	2.50	3.13	3.75	4.38	5.00	5.63	6.25	6.88	30.00
$\frac{13}{16}$	2.71	3.39	4.06	4.74	5.42	6.09	6.77	7.45	32.50
$\frac{7}{8}$	2.92	3.65	4.38	5.10	5.83	6.56	7.29	8.02	35.00
$\frac{15}{16}$	3.13	3.91	4.69	5.47	6.25	7.03	7.81	8.59	37.50
1	3.33	4.17	5.00	5.83	6.67	7.50	8.33	9.17	40.00
$1\frac{1}{16}$	3.54	4.43	5.31	6.20	7.08	7.97	8.85	9.74	42.50
$1\frac{1}{8}$	3.75	4.69	5.63	6.56	7.50	8.44	9.38	10.31	45.00
$1\frac{3}{16}$	3.96	4.95	5.94	6.93	7.92	8.91	9.90	10.89	47.50
$1\frac{1}{4}$	4.17	5.21	6.25	7.29	8.33	9.38	10.42	11.46	50.00
$1\frac{5}{16}$	4.37	5.47	6.56	7.66	8.75	9.84	10.94	12.03	52.50
$1\frac{3}{8}$	4.58	5.73	6.88	8.02	9.17	10.31	11.46	12.60	55.00
$1\frac{7}{16}$	4.79	5.99	7.19	8.39	9.58	10.78	11.98	13.18	57.50
$1\frac{1}{2}$	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	60.00
$1\frac{9}{16}$	5.21	6.51	7.81	9.11	10.42	11.72	13.02	14.32	62.50
$1\frac{5}{8}$	5.42	6.77	8.13	9.48	10.83	12.19	13.54	14.90	65.00
$1\frac{11}{16}$	5.63	7.03	8.44	9.84	11.25	12.66	14.06	15.47	67.50
$1\frac{3}{4}$	5.83	7.29	8.75	10.21	11.67	13.13	14.58	16.04	70.00
$1\frac{13}{16}$	6.04	7.55	9.06	10.57	12.08	13.59	15.10	16.61	72.50
$1\frac{7}{8}$	6.25	7.81	9.38	10.94	12.50	14.06	15.63	17.19	75.00
$1\frac{15}{16}$	6.46	8.07	9.69	11.30	12.92	14.53	16.15	17.76	77.50
2	6.67	8.33	10.00	11.67	13.33	15.00	16.67	18.33	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAR FOOT.

(Continued)

Thickness in Inches.	3″	3¼″	3½″	3¾″	4″	4¼″	4½″	4¾″	12″
1/16	.625	.677	.729	.781	.833	.885	.938	.990	2.50
1/8	1.25	1.35	1.46	1.56	1.67	1.77	1.88	1.98	5.00
3/16	1.88	2.03	2.19	2.34	2.50	2.66	2.81	2.97	7.50
1/4	2.50	2.71	2.92	3.13	3.33	3.54	3.75	3.96	10.00
5/16	3.13	3.39	3.65	3.91	4.17	4.43	4.69	4.95	12.50
3/8	3.75	4.06	4.38	4.69	5.00	5.31	5.63	5.94	15.00
7/16	4.38	4.74	5.10	5.47	5.83	6.20	6.56	6.93	17.50
1/2	5.00	5.42	5.83	6.25	6.67	7.08	7.50	7.92	20.00
9/16	5.63	6.09	6.56	7.03	7.50	7.97	8.44	8.91	22.50
5/8	6.25	6.77	7.29	7.81	8.33	8.85	9.38	9.90	25.00
11/16	6.88	7.45	8.02	8.59	9.17	9.74	10.31	10.89	27.50
3/4	7.50	8.13	8.75	9.38	10.00	10.63	11.25	11.88	30.00
13/16	8.13	8.80	9.48	10.16	10.83	11.51	12.19	12.86	32.50
7/8	8.75	9.48	10.21	10.94	11.67	12.40	13.13	13.85	35.00
15/16	9.38	10.16	10.94	11.72	12.50	13.28	14.06	14.84	37.50
1	10.00	10.83	11.67	12.50	13.33	14.17	15.00	15.83	40.00
1 1/16	10.63	11.51	12.40	13.28	14.17	15.05	15.94	16.82	42.50
1 1/8	11.25	12.19	13.13	14.06	15.00	15.94	16.88	17.81	45.00
1 3/16	11.88	12.86	13.85	14.84	15.83	16.82	17.81	18.80	47.50
1 1/4	12.50	13.54	14.58	15.63	16.67	17.71	18.75	19.79	50.00
1 5/16	13.13	14.22	15.31	16.41	17.50	18.59	19.69	20.78	52.50
1 3/8	13.75	14.90	16.04	17.19	18.33	19.48	20.63	21.77	55.00
1 7/16	14.38	15.57	16.77	17.97	19.17	20.36	21.56	22.76	57.50
1 1/2	15.00	16.25	17.50	18.75	20.00	21.25	22.50	23.75	60.00
1 9/16	15.63	16.93	18.23	19.53	20.83	22.14	23.44	24.74	62.50
1 5/8	16.25	17.60	18.96	20.31	21.67	23.02	24.38	25.73	65.00
1 11/16	16.88	18.28	19.69	21.09	22.50	23.91	25.31	26.72	67.50
1 3/4	17.50	18.96	20.42	21.88	23.33	24.79	26.25	27.71	70.00
1 13/16	18.13	19.64	21.15	22.66	24.17	25.68	27.19	28.70	72.50
1 7/8	18.75	20.31	21.88	23.44	25.00	26.56	28.13	29.69	75.00
1 15/16	19.38	20.99	22.60	24.22	25.83	27.45	29.06	30.68	77.50
2	20.00	21.67	23.33	25.00	26.67	28.33	30.00	31.67	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAR FOOT.

(Continued)

Thickness in Inches.	5″	5¼″	5½″	5¾″	6″	6¼″	6½″	6¾″	12″
1/16	1.04	1.09	1.15	1.20	1.25	1.30	1.35	1.41	2.50
1/8	2.08	2.19	2.29	2.40	2.50	2.60	2.71	2.81	5.00
3/16	3.13	3.28	3.44	3.59	3.75	3.91	4.06	4.22	7.50
1/4	4.17	4.38	4.58	4.79	5.00	5.21	5.42	5.63	10.00
5/16	5.21	5.47	5.73	5.99	6.25	6.51	6.77	7.03	12.50
3/8	6.25	6.56	6.88	7.19	7.50	7.81	8.13	8.44	15.00
7/16	7.29	7.66	8.02	8.39	8.75	9.11	9.48	9.84	17.50
1/2	8.33	8.75	9.17	9.58	10.00	10.42	10.83	11.25	20.00
9/16	9.38	9.84	10.31	10.78	11.25	11.72	12.19	12.66	22.50
5/8	10.42	10.94	11.46	11.98	12.50	13.02	13.54	14.06	25.00
11/16	11.46	12.03	12.60	13.18	13.75	14.32	14.90	15.47	27.50
3/4	12.50	13.13	13.75	14.38	15.00	15.63	16.25	16.88	30.00
13/16	13.54	14.22	14.90	15.57	16.25	16.93	17.60	18.28	32.50
7/8	14.58	15.31	16.04	16.77	17.50	18.23	18.96	19.69	35.00
15/16	15.63	16.41	17.19	17.97	18.75	19.53	20.31	21.09	37.50
1	16.67	17.50	18.33	19.17	20.00	20.83	21.67	22.50	40.00
1 1/16	17.71	18.59	19.48	20.36	21.25	22.14	23.02	23.91	42.50
1 1/8	18.75	19.69	20.63	21.56	22.50	23.44	24.38	25.31	45.00
1 3/16	19.79	20.78	21.77	22.76	23.75	24.74	25.73	26.72	47.50
1 1/4	20.83	21.88	22.92	23.96	25.00	26.04	27.08	28.13	50.00
1 5/16	21.88	22.97	24.06	25.16	26.25	27.34	28.44	29.53	52.50
1 3/8	22.92	24.06	25.21	26.35	27.50	28.65	29.79	30.94	55.00
1 7/16	23.96	25.16	26.35	27.55	28.75	29.95	31.15	32.34	57.50
1 1/2	25.00	26.25	27.50	28.75	30.00	31.25	32.50	33.75	60.00
1 9/16	26.04	27.34	28.65	29.95	31.25	32.55	33.85	35.16	62.50
1 5/8	27.08	28.44	29.79	31.15	32.50	33.85	35.21	36.56	65.00
1 11/16	28.13	29.53	30.94	32.34	33.75	35.16	36.56	37.97	67.50
1 3/4	29.17	30.63	32.08	33.54	35.00	36.46	37.92	39.38	70.00
1 13/16	30.21	31.72	33.23	34.74	36.25	37.76	39.27	40.78	72.50
1 7/8	31.25	32.81	34.38	35.94	37.50	39.06	40.63	42.19	75.00
1 15/16	32.29	33.91	35.52	37.14	38.75	40.36	41.98	43.59	77.50
2	33.33	35.00	36.67	38.33	40.00	41.67	43.33	45.00	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAR FOOT.

(Continued)

Thickness in Inches.	7″	7¼″	7½″	7¾″	8″	8¼″	8½″	8¾″	12″
1/16	1.46	1.51	1.56	1.61	1.67	1.72	1.77	1.82	2.50
1/8	2.92	3.02	3.13	3.23	3.33	3.44	3.54	3.65	5.00
3/16	4.38	4.53	4.69	4.84	5.00	5.16	5.31	5.47	7.50
1/4	5.83	6.04	6.25	6.46	6.67	6.88	7.08	7.29	10.00
5/16	7.29	7.55	7.81	8.07	8.33	8.59	8.85	9.11	12.50
3/8	8.75	9.06	9.38	9.69	10.00	10.31	10.63	10.94	15.00
7/16	10.21	10.57	10.94	11.30	11.67	12.03	12.40	12.76	17.50
1/2	11.67	12.08	12.50	12.92	13.33	13.75	14.17	14.58	20.00
9/16	13.13	13.59	14.06	14.53	15.00	15.47	15.94	16.41	22.50
5/8	14.58	15.10	15.63	16.15	16.67	17.19	17.71	18.23	25.00
11/16	16.04	16.61	17.19	17.76	18.33	18.91	19.48	20.05	27.50
3/4	17.50	18.13	18.75	19.38	20.00	20.63	21.25	21.88	30.00
13/16	18.96	19.64	20.31	20.99	21.67	22.34	23.02	23.70	32.50
7/8	20.42	21.15	21.88	22.60	23.33	24.06	24.79	25.52	35.00
15/16	21.88	22.66	23.44	24.22	25.00	25.78	26.56	27.34	37.50
1	23.33	24.17	25.00	25.83	26.67	27.50	28.33	29.17	40.00
1 1/16	24.79	25.68	26.56	27.45	28.33	29.22	30.10	30.99	42.50
1 1/8	26.25	27.19	28.13	29.06	30.00	30.94	31.88	32.81	45.00
1 3/16	27.71	28.70	29.69	30.68	31.67	32.66	33.65	34.64	47.50
1 1/4	29.17	30.21	31.25	32.29	33.33	34.38	35.42	36.46	50.00
1 5/16	30.62	31.72	32.81	33.91	35.00	36.09	37.19	38.28	52.50
1 3/8	32.08	33.23	34.38	35.52	36.67	37.81	38.96	40.10	55.00
1 7/16	33.54	34.74	35.94	37.14	38.33	39.53	40.73	41.93	57.50
1 1/2	35.00	36.25	37.50	38.75	40.00	41.25	42.50	43.75	60.00
1 9/16	36.46	37.76	39.06	40.36	41.67	42.97	44.27	45.57	62.50
1 5/8	37.92	39.27	40.63	41.98	43.33	44.69	46.04	47.40	65.00
1 11/16	39.38	40.78	42.19	43.59	45.00	46.41	47.81	49.22	67.50
1 3/4	40.83	42.29	43.75	45.21	46.67	48.13	49.58	51.04	70.00
1 13/16	42.29	43.80	45.31	46.82	48.33	49.84	51.35	52.86	72.50
1 7/8	43.75	45.31	46.88	48.44	50.00	51.56	53.13	54.69	75.00
1 15/16	45.21	46.82	48.44	50.05	51.67	53.28	54.90	56.51	77.50
2	46.67	48.33	50.00	51.67	53.33	55.00	56.67	58.33	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAR FOOT.

(Continued)

Thickness in Inches.	9″	9¼″	9½″	9¾″	10″	10¼″	10½″	10¾″	12″
1/16	1.88	1.93	1.98	2.03	2.08	2.14	2.19	2.24	2.50
1/8	3.75	3.85	3.96	4.06	4.17	4.27	4.38	4.48	5.00
3/16	5.63	5.78	5.94	6.09	6.25	6.41	6.56	6.72	7.50
1/4	7.50	7.71	7.92	8.13	8.33	8.54	8.75	8.96	10.00
5/16	9.38	9.64	9.90	10.16	10.42	10.68	10.94	11.20	12.50
3/8	11.25	11.56	11.88	12.19	12.50	12.81	13.13	13.44	15.00
7/16	13.13	13.49	13.85	14.22	14.58	14.95	15.31	15.68	17.50
1/2	15.00	15.42	15.83	16.25	16.67	17.08	17.50	17.92	20.00
9/16	16.88	17.34	17.81	18.28	18.75	19.22	19.69	20.16	22.50
5/8	18.75	19.27	19.79	20.31	20.83	21.35	21.88	22.40	25.00
11/16	20.63	21.20	21.77	22.34	22.92	23.49	24.06	24.64	27.50
3/4	22.50	23.13	23.75	24.38	25.00	25.62	26.25	26.88	30.00
13/16	24.38	25.05	25.73	26.41	27.08	27.76	28.44	29.11	32.50
7/8	26.25	26.98	27.71	28.44	29.17	29.90	30.63	31.35	35.00
15/16	28.13	28.91	29.69	30.47	31.25	32.03	32.81	33.59	37.50
1	30.00	30.83	31.67	32.50	33.33	34.17	35.00	35.83	40.00
1 1/16	31.88	32.76	33.65	34.53	35.42	36.30	37.19	38.07	42.50
1 1/8	33.75	34.69	35.63	36.56	37.50	38.44	39.38	40.31	45.00
1 3/16	35.63	36.61	37.60	38.59	39.58	40.57	41.56	42.55	47.50
1 1/4	37.50	38.54	39.58	40.63	41.67	42.71	43.75	44.79	50.00
1 5/16	39.38	40.47	41.56	42.66	43.75	44.84	45.94	47.03	52.50
1 3/8	41.25	42.40	43.54	44.69	45.83	46.98	48.13	49.27	55.00
1 7/16	43.13	44.32	45.52	46.72	47.92	49.11	50.31	51.51	57.50
1 1/2	45.00	46.25	47.50	48.75	50.00	51.25	52.50	53.75	60.00
1 9/16	46.88	48.18	49.48	50.78	52.08	53.39	54.69	55.99	62.50
1 5/8	48.75	50.10	51.46	52.81	54.17	55.52	56.88	58.23	65.00
1 11/16	50.63	52.03	53.44	54.84	56.25	57.66	59.06	60.47	67.50
1 3/4	52.50	53.96	55.42	56.88	58.33	59.79	61.25	62.71	70.00
1 13/16	54.38	55.89	57.40	58.91	60.42	61.93	63.44	64.95	72.50
1 7/8	56.25	57.81	59.38	60.94	62.50	64.06	65.63	67.19	75.00
1 15/16	58.13	59.74	61.35	62.97	64.58	66.20	67.81	69.43	77.50
2	60.00	61.67	63.33	65.00	66.67	68.33	70.00	71.67	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAR FOOT.

(Concluded)

Thickness in Inches.	11"	11¼"	11½"	11¾"	12"	12¼"	12½"	12¾"
1/16	2.29	2.34	2.40	2.45	2.50	2.55	2.60	2.66
1/8	4.58	4.69	4.79	4.90	5.00	5.10	5.21	5.31
3/16	6.88	7.03	7.19	7.34	7.50	7.66	7.81	7.97
1/4	9.17	9.38	9.58	9.79	10.00	10.21	10.42	10.63
5/16	11.46	11.72	11.98	12.24	12.50	12.76	13.02	13.28
3/8	13.75	14.06	14.38	14.69	15.00	15.31	15.63	15.94
7/16	16.04	16.41	16.77	17.14	17.50	17.86	18.23	18.59
1/2	18.33	18.75	19.17	19.58	20.00	20.42	20.83	21.25
9/16	20.63	21.09	21.56	22.03	22.50	22.97	23.44	23.91
5/8	22.92	23.44	23.96	24.48	25.00	25.52	26.04	26.56
11/16	25.21	25.78	26.35	26.93	27.50	28.07	28.65	29.22
3/4	27.50	28.13	28.75	29.38	30.00	30.63	31.25	31.88
13/16	29.79	30.47	31.15	31.82	32.50	33.18	33.85	34.53
7/8	32.08	32.81	33.54	34.27	35.00	35.73	36.46	37.19
15/16	34.38	35.16	35.94	36.72	37.50	38.28	39.06	39.84
1	36.67	37.50	38.33	39.17	40.00	40.83	41.67	42.50
1 1/16	38.96	39.84	40.73	41.61	42.50	43.39	44.27	45.16
1 1/8	41.25	42.19	43.13	44.06	45.00	45.94	46.88	47.81
1 3/16	43.54	44.53	45.52	46.51	47.50	48.49	49.48	50.47
1 1/4	45.83	46.88	47.92	48.96	50.00	51.04	52.08	53.13
1 5/16	48.13	49.22	50.31	51.41	52.50	53.59	54.69	55.78
1 3/8	50.42	51.56	52.71	53.85	55.00	56.15	57.29	58.44
1 7/16	52.71	53.91	55.10	56.30	57.50	58.70	59.90	61.09
1 1/2	55.00	56.25	57.50	58.75	60.00	61.25	62.50	63.75
1 9/16	57.29	58.59	59.90	61.20	62.50	63.80	65.10	66.41
1 5/8	59.58	60.94	62.29	63.65	65.00	66.35	67.71	69.06
1 11/16	61.88	63.28	64.69	66.09	67.50	68.91	70.31	71.72
1 3/4	64.17	65.63	67.08	68.54	70.00	71.46	72.92	74.38
1 13/16	66.46	67.97	69.48	70.99	72.50	74.01	75.52	77.03
1 7/8	68.75	70.31	71.88	73.44	75.00	76.56	78.13	79.69
1 15/16	71.04	72.66	74.27	75.89	77.50	79.11	80.73	82.34
2	73.33	75.00	76.67	78.33	80.00	81.67	83.33	85.00

The weights for 12" width are repeated on each page to facilitate making the additions necessary for plates wider than 12". Thus, to find the weight of 15¾" x ⅞", add the weights to be found in the same line for 3¾" x ⅞" and 12" x ⅞" = 9.48 + 35.00 = 44.48 lbs.

SQUARE AND ROUND IRON BARS.

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of ⊡ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
0					
1/16	.013	.010	.0039	.0031	.1963
1/8	.052	.041	.0156	.0123	.3927
3/16	.117	.092	.0352	.0276	.5890
1/4	.208	.164	.0625	.0491	.7854
5/16	.326	.256	.0977	.0767	.9817
3/8	.469	.368	.1406	.1104	1.1781
7/16	.638	.501	.1914	.1503	1.3744
1/2	.833	.654	.2500	.1963	1.5708
9/16	1.055	.828	.3164	.2485	1.7671
5/8	1.302	1.023	.3906	.3068	1.9635
11/16	1.576	1.237	.4727	.3712	2.1598
3/4	1.875	1.473	.5625	.4418	2.3562
13/16	2.201	1.728	.6602	.5185	2.5525
7/8	2.552	2.004	.7656	.6013	2.7489
15/16	2.930	2.301	.8789	.6903	2.9452
1	3.333	2.618	1.0000	.7854	3.1416
1/16	3.763	2.955	1.1289	.8866	3.3379
1/8	4.219	3.313	1.2656	.9940	3.5343
3/16	4.701	3.692	1.4102	1.1075	3.7306
1/4	5.208	4.091	1.5625	1.2272	3.9270
5/16	5.742	4.510	1.7227	1.3530	4.1233
3/8	6.302	4.950	1.8906	1.4849	4.3197
7/16	6.888	5.410	2.0664	1.6230	4.5160
1/2	7.500	5.890	2.2500	1.7671	4.7124
9/16	8.138	6.392	2.4414	1.9175	4.9087
5/8	8.802	6.913	2.6406	2.0739	5.1051
11/16	9.492	7.455	2.8477	2.2365	5.3014
3/4	10.21	8.018	3.0625	2.4053	5.4978
13/16	10.95	8.601	3.2852	2.5802	5.6941
7/8	11.72	9.204	3.5156	2.7612	5.8905
15/16	12.51	9.828	3.7539	2.9483	6.0868
2	13.33	10.47	4.0000	3.1416	6.2832
1/16	14.18	11.14	4.2539	3.3410	6.4795
1/8	15.05	11.82	4.5156	3.5466	6.6759
3/16	15.95	12.53	4.7852	3.7583	6.8722
1/4	16.88	13.25	5.0625	3.9761	7.0686
5/16	17.83	14.00	5.3477	4.2000	7.2649
3/8	18.80	14.77	5.6406	4.4301	7.4613
7/16	19.80	15.55	5.9414	4.6664	7.6576
1/2	20.83	16.36	6.2500	4.9087	7.8540
9/16	21.89	17.19	6.5664	5.1572	8.0503
5/8	22.97	18.04	6.8906	5.4119	8.2467
11/16	24.08	18.91	7.2227	5.6727	8.4430

SQUARE AND ROUND IRON BARS.

(Concluded)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
3/4	25.21	19.80	7.5625	5.9396	8.6394
13/16	26.37	20.71	7.9102	6.2126	8.8357
7/8	27.55	21.64	8.2656	6.4918	9.0321
15/16	28.76	22.59	8.6289	6.7771	9.2284
3	30.00	23.56	9.0000	7.0686	9.4248
1/16	31.26	24.55	9.3789	7.3662	9.6211
1/8	32.55	25.57	9.7656	7.6699	9.8175
3/16	33.87	26.60	10.160	7.9798	10.014
1/4	35.21	27.65	10.563	8.2958	10.210
5/16	36.58	28.73	10.973	8.6179	10.407
3/8	37.97	29.82	11.391	8.9462	10.603
7/16	39.39	30.94	11.816	9.2806	10.799
1/2	40.83	32.07	12.250	9.6211	10.996
9/16	42.30	33.23	12.691	9.9678	11.192
5/8	43.80	34.40	13.141	10.321	11.388
11/16	45.33	35.60	13.598	10.680	11.585
3/4	46.88	36.82	14.063	11.045	11.781
13/16	48.45	38.05	14.535	11.416	11.977
7/8	50.05	39.31	15.016	11.793	12.174
15/16	51.68	40.59	15.504	12.177	12.370
4	53.33	41.89	16.000	12.566	12.566
1/16	55.01	43.21	16.504	12.962	12.763
1/8	56.72	44.55	17.016	13.364	12.959
3/16	58.45	45.91	17.535	13.772	13.155
1/4	60.21	47.29	18.063	14.186	13.352
5/16	61.99	48.69	18.598	14.607	13.548
3/8	63.80	50.11	19.141	15.033	13.744
7/16	65.64	51.55	19.691	15.466	13.941
1/2	67.50	53.01	20.250	15.904	14.137
9/16	69.39	54.50	20.816	16.349	14.334
5/8	71.30	56.00	21.391	16.800	14.530
11/16	73.24	57.52	21.973	17.257	14.726
3/4	75.21	59.07	22.563	17.721	14.923
13/16	77.20	60.63	23.160	18.190	15.119
7/8	79.22	62.22	23.766	18.665	15.315
15/16	81.26	63.82	24.379	19.147	15.512
5	83.33	65.45	25.000	19.635	15.708

ANGLE IRON.

Weight Per Linear Foot.

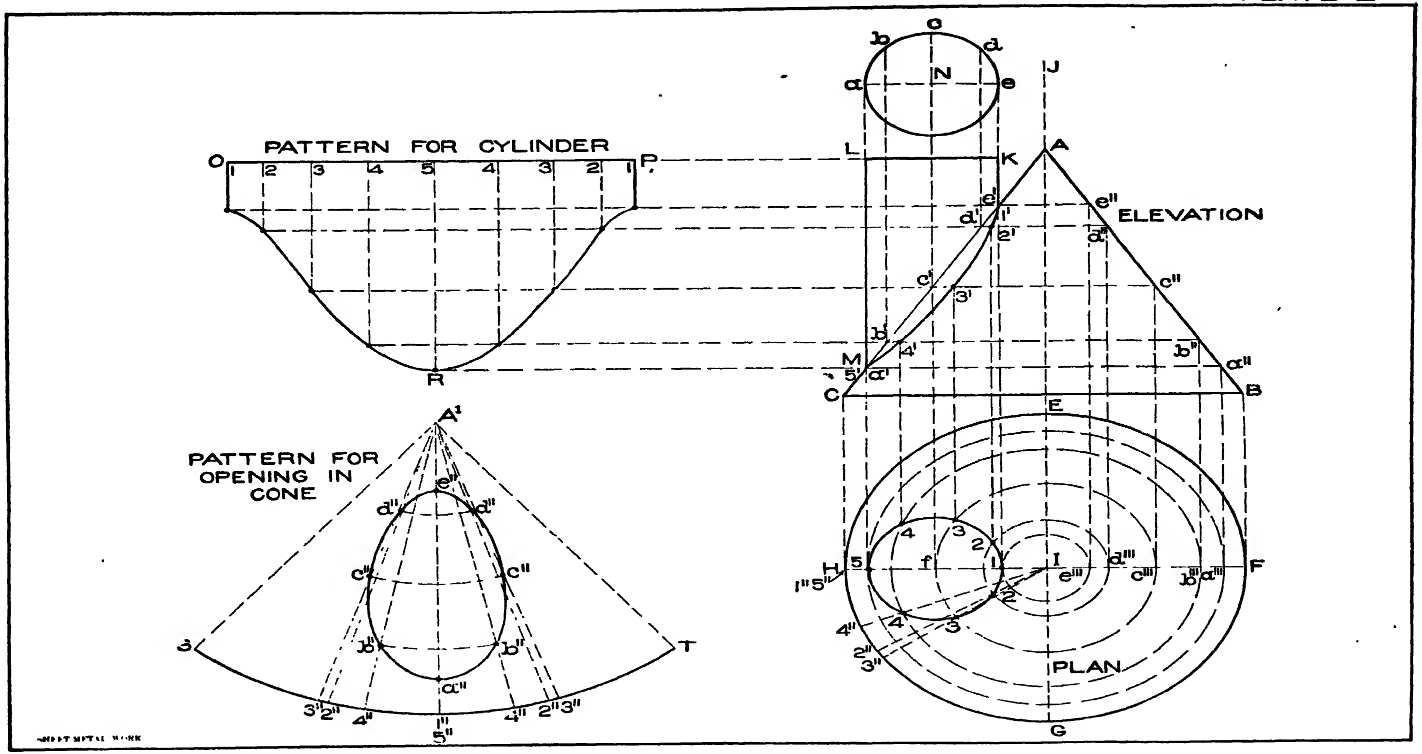
6 x 6 x 5/8	24 Lbs.	2 x 2 x 1/4	3½ Lbs.
5 x 5 x 9/16	16½ "	1¾ x 1¾ x 3/16	2¾ "
4 x 4 x ½	12½ "	1½ x 1½ x 3/16	2 "
3½ x 3½ x 7/16	9 "	1¼ x 1¼ x 3/16	1½ "
3 x 3 x 3/8	7 "	1 x 1 x 1/8	1 "
2½ x 2½ x 5/16	5 "	¾ x ¾ x 1/8	5/8 "
2¼ x 2¼ x ¼	4¼ "		

TEE IRON.

Weight Per Linear Foot.

5 x 8 x 5/8	30 Lbs.	2¼ x 2¼ x ¼	4 Lbs
7 x 6 x 5/8	30 "	2 x 2 x ¼	3¼ "
6 x 3 x ½	16½ "	1¾ x 1¾ x ¼	3 "
4 x 4 x ½	14 "	1½ x 1½ x ¼	2¾ "
3½ x 3½ x ½	12½ "	1¼ x 1¼ x ¼	2¼ "
3 x 3 x 3/8	7¼ "	1 x 1 x 1/8	1 "
2½ x 2½ x ½	8 "	¾ x ¾ x 1/8	5/8 "
2½ x 2½ x 5/16	5 "		

PLATE I


PATTERN FOR CYLINDER
ELEVATION
PLAN
PATTERN FOR OPENING IN CONE
SHEET METAL WORK

EXAMINATION PLATES.

PLATE I.

The plates of this Instruction Paper should be laid out the same size as explained in the course on Tinsmith's Work. Before starting these plates the student should first practice on other paper and make models of stiff cardboard to prove the accuracy of the patterns. When the problem is thoroughly mastered and understood, copy and send in your best drawing for examination and correction.

The first problem given is the intersection and development of a cylinder and a right cone, whose lines of axis run parallel to each other. First draw the base of the cone B C $4\frac{1}{4}$ inches long, placing B $1\frac{1}{2}$ inches from the border line, and the line C B $5\frac{1}{4}$ inches above the bottom line. Make the vertical height of the cone $3\frac{1}{2}$ inches, and draw the lines A B and A C. Through A draw the center vertical line J G, on which $2\frac{1}{2}$ inches below the base line C B establish the point I. Now with I as center and $\frac{1}{2}$ of C B as radius, describe the circle E F G H, which represents the plan of the cone. From A on the line A C measure down one inch as shown at e', from which erect a vertical line e' K $\frac{3}{4}$-inch high. From K draw the horizontal line K L equal to $1\frac{3}{8}$ inches, and from L drop a perpendicular intersecting the side of the cone at M. Directly above L K in its proper relative position $\frac{1}{4}$-inch above L K, with N as center draw the circle shown, which represents a section through L K. Through the center N draw the horizontal line a e. Now divide the half upper section N into an equal number of spaces as shown by a b c d e, from which points drop vertical lines intersecting the side of the cone A C at a' b' c' d' and e', and from these points, draw horizontal lines, intersecting the opposite side A B from a'' to e''.

The next step is to construct planes in plan as follows: From the various intersections a'' to e'' in elevation, drop vertical lines intersecting the horizontal line H F in plan drawn through the center I, at a''' b''' c''' d''' and e'''. Then using I as center and distances to points a''' to e''' as radii, strike the various circles shown. From the center of the section N in elevation extend the line intersecting H F in plan at f; then using f as center and N a

or N e in elevation as radius, describe the circle 1–3–5–3 in plan, cutting the various planes at 1, 2, 3, 4, and 5 on both sides. Now, from the various points of intersection on the various planes in plan, erect lines intersecting similarly lettered planes in elevation as shown at 1′, 2′, 3′, 4′, and 5′, through which trace a line as shown, which represents the line of intersection between the cylinder and right cone.

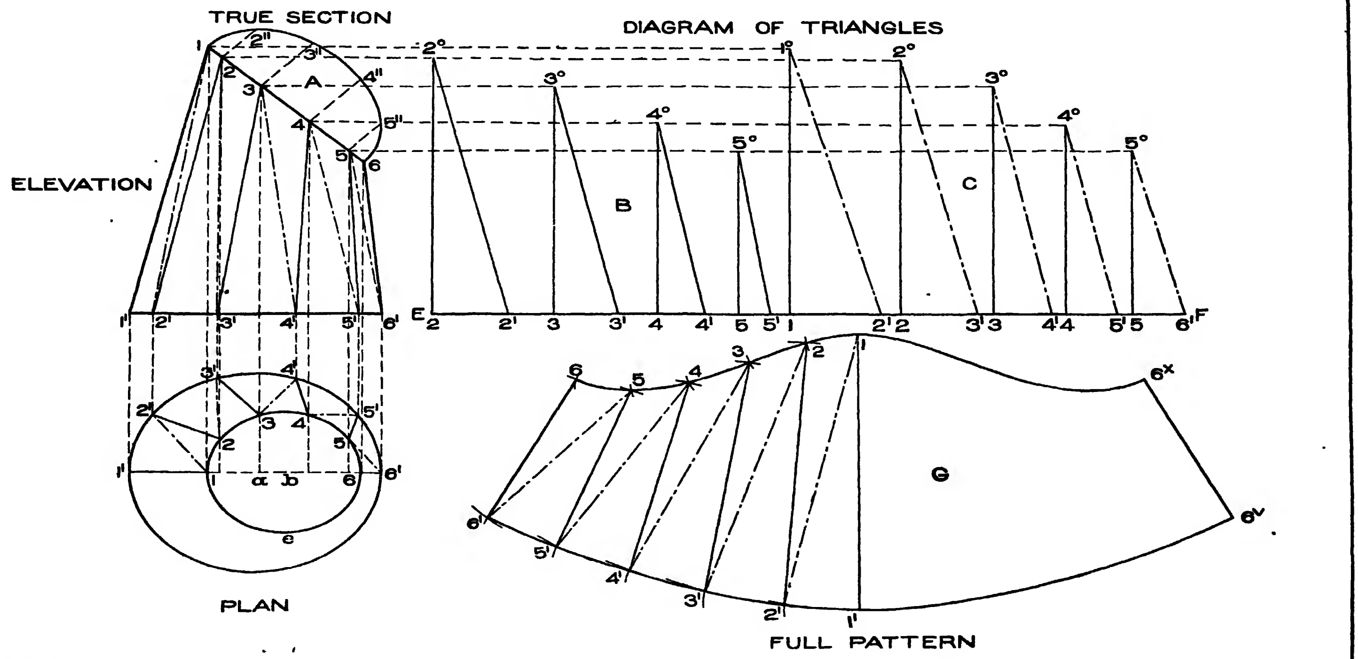
For the pattern for the cylinder proceed as follows: Extend the line K L of the cylinder in elevation as shown by O P, placing the distance 1 from the margin line $2\frac{1}{2}$ inches. Now starting from 1, lay off on O P the stretchout of the section f in plan, the spaces being designated by similar figures on O P. From these small figures and at right angles to O P, draw lines which intersect with lines drawn from similarly numbered intersections on the line of intersection in elevation parallel to O P. Trace a line through points thus obtained. Then will O P R be the full pattern for the cylinder.

The pattern for the right cone is developed as has already been described in the Tinsmith's Course, and for that reason will be shown only the method how to obtain the pattern for the opening in the cone to miter with the cylinder. For this proceed as follows: Draw radial lines from I in plan through the intersections 1, 2, 3, 4, and 5, cutting the outer curve E F G H at 1″. 2″, 3″, 4″, and 5″, respectively. Now with A B in elevation as radius and A^1 as center, describe a short arc as S T. Place the arc as far above the margin line as the plan G, and have S T central between the plan and margin line. From A^1 drop a vertical line intersecting the arc S T at 1″. Now starting from 1″, set off on either side of the center line A^1 1″ the distances shown in plan from 1″ 5″ to 4″ to 2″ to 3″, as shown by similar numbers on S T. From these points draw radial lines to A^1. Now using A^1 as center and with radii equal to A e', A d', A c', A b', and A a' in elevation, describe arcs intersecting respectively the radial lines A′ 1″ at e'', 2″ 2″ at d'' d'', 3″ 3″ at c'' c'', 4″ 4″ at b'' b'', and A′ 5″ at a''. Through these intersections trace a line as shown, which will be the desired opening.

HOUSE AT MONTECITO, CALIFORNIA

Myron Hunt & Elmer Grey, Architects, Los Angeles, Cal.

Cost, Approximately, $40,000. Walls of Local Stone. Roofs of Japanese Tile of Metallic Composition Containing Aluminum and other Ingredients which, under Erosion of the Weather, Become Partially Disintegrated, Giving Beautiful Bronze Color Effects. For Plans, See Page 154; for View of Terrace, See Page 186.



TRUE SECTION
DIAGRAM OF TRIANGLES
ELEVATION
PLAN
FULL PATTERN
A
B
C
G
E
F

PLATE II.

This problem will give an examination on triangulation, being the development of an irregular solid whose bottom and top are round when viewed on horizontal planes, the top plane being cut off at an angle of 45° to the base line. First draw the base line 1′–6′, $2\frac{3}{4}$ inches long, placing the point 1′ 2 inches from the margin line, and the line 1′–6′ in the center of the sheet. Three inches above the bottom margin line draw the horizontal line 1′–6′ in plan; then with *a* as center and radius equal to one-half of 1′–6′ in elevation, draw the circle shown in its proper position below the line 1′–6′ in elevation. Now $\frac{1}{4}$ inch to the right of *a* on the line 1′–6′ in plan, establish *b*, which use as a center, and with $\frac{13}{16}$-inch radius describe the inner circle 1–3–6–*e*, which represents the upper horizontal plane of the irregular article. From the points 1 and 6 in plan, erect the vertical lines 1–1 and 6–6, making the height of the line 1–1 above the base line 1′–6′ in elevation $3\frac{3}{4}$ inches, and from the point 1 in elevation draw the line 1–6 at an angle of 45° intersecting the vertical line 6–6 at 6. Now draw lines from 1 to 1′ and from 6 to 6′, which completes the elevation.

Now divide the half plan into an equal number of parts (in this case 5) as shown by the small figures 1′ to 6′. In the same manner divide the inner circle into the same number of parts as shown from 1 to 6. Now draw solid lines from 1′ to 1, 2′ to 2, 3′ to 3, 4′ to 4, 5′ to 5, and 6′ to 6; and dotted lines from 1 to 2′, 2 to 3′, 3 to 4′, 4 to 5′, and 5 to 6′. From the intersections 1′ to 6′ on the outer plan, erect lines intersecting the base line in elevation from 1′ to 6′. In a similar manner, from the intersections on the inner curve in plan erect lines intersecting the top plane of he article from 1 to 6. Now connect lines in elevation from 2 to 2′, 3 to 3′, etc., although these lines are not necessary in the development of the pattern, but are given only to show their relationship to similar lines in plan. The solid and dotted lines in plan represent the bases of triangles, which will be constructed, whose altitudes are equal to similarly numbered vertical heights in elevation. The construction of these triangles is shown at B and C, B representing the triangles on solid lines in plan, and C the triangles on dotted lines in plan. Construct these triangles as

follows: Extend the line 1′–6′ in elevation as E F, the point 6′ on E F to be placed 1 inch from the margin line. Now take the various distances of the dotted lines in plan as 6′ to 5, 5′ to 4. 4′ to 3, 3′ to 2, and 2′ to 1, and place them on the line E F as shown by similar numbers. Now from the small figures 1, 2, 3, 4, and 5 on the line E F, erect lines, which intersect by lines drawn from similarly numbered intersections on 1–6 in elevation, parallel to E F, thus obtaining the points 1°, 2°, 3°, 4°, and 5°. Then draw lines from 1° to 2′, 2° to 3′, 3° to 4′, 4° to 5′, and 5° to 6′, which will represent the diagram of triangles on dotted lines in plan, the slant lines representing the true lengths on the finished article. In precisely the same manner obtain the diagram of triangles B on solid lines in plan. For example, take the distance of 2–2′ in plan, and place it as shown by 2–2′ on the line E F; from 2 at right angles to E F draw the line 2–2° equal to the vertical height to 2 in elevation, and draw a line from 2° to 2′, which is the true length on 2–2′ in plan. It now becomes necessary to obtain a true section on the line 1–6 in elevation. Therefore at right angles to 1–6 and from the various intersections 1 to 6, draw lines as shown. Now measuring in each instance from the line 1′–6′ in plan, take the various distances to points 2, 3, 4, and 5, and place them in A on similarly numbered lines, measuring in each instance from the line 1–6 in elevation, thus obtaining the points 2″ to 5″. A line traced as shown will be the half section on 1–6 in elevation.

For the pattern proceed as follows: Draw any line as 1–1′ in G equal to 1–1′ in elevation. Now with radius equal to 1′–2′ in plan, and 1′ in G as center, describe the arc 2′. Then using 1 in G as center, and 1°–2′ in C as radius, intersect the arc 2′ in G. Now with radius equal to 1–2″ in the true section, and 1 in G as center, describe the arc 2, which intersect by an arc struck from 2′ as center and with 2°–2′ in B as radius. Proceed in this manner, using alternately as radii, first the divisions in the outer curve in plan, then the hypothenuses or slant lines in C; the divisions in the true section A, then the length of the slant lines in B, following the numbers in regular order until the last line 6–6′ in G is obtained, this line being obtained from 6–6′ in elevation. Trace lines as shown from 1 to 6 and from 1′ to 6′, which give the half

pattern. Trace the other half opposite the line 1–1′ as shown by 6^x 6^v. Then will 6–1-6^x–6^v–1′–6′ be the full pattern with joint at 6–6′ in elevation

VENTILATION WORK *

In the illustration is shown a system of ventilation, in which the various pipes are led from brick or metal flues to the attic as shown, and connected to the sheet metal drum.

This drum is made in size equal to the combined area of all pipes entering same. The drum is set upon a wooden platform as shown and has a clean-out door made large enough to admit a man's body. Steam coils are placed inside to create a suction, when the heated air rises through the ventilator. The drum is connected to the ventilator as shown, the bracing of the ventilator being fastened to the inside of the curb.

The detail at the right shows the connection joint between the pipe and drum, while that at the left shows the construction of the metal door and frame. with method of fastening to the body of the drum.

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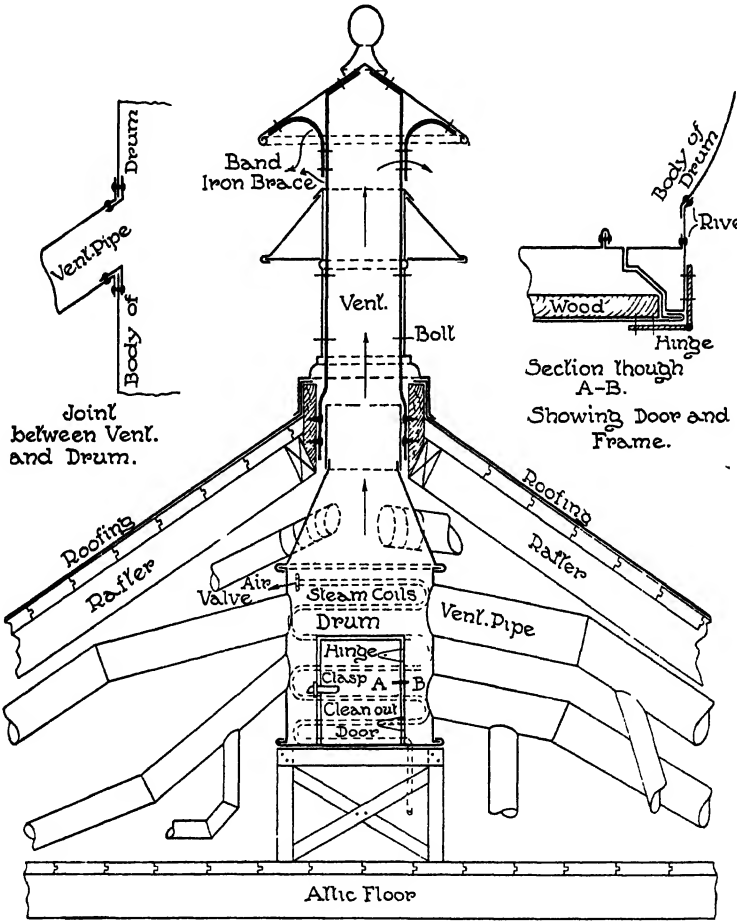
* The illustration referred to will be found on the back of this page.

CONSTRUCTION DRAWING
SHOWING
SHEET METAL DRUM AND VENTILATOR IN VENTILATION WORK



Sectional view showing ventilation pipes connected to drum in attic also steam coils in drum to create suction.

FOR EXPLANATION OF THIS PROBLEM SEE BACK OF PAGE

SHEET METAL WORK.

PART II.

PROBLEMS FOR LIGHT GAUGE METAL.

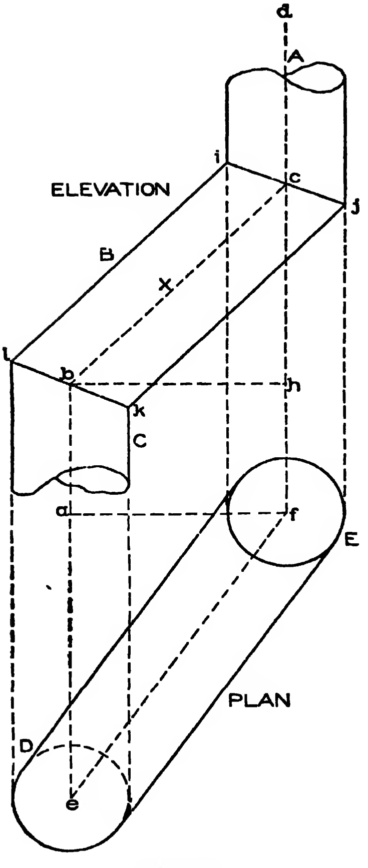


Fig. 65.

It is often the case that the sheet metal worker receives plans for vent, heat, or blower pipes to be constructed, in which the true lengths and angles are not shown but must be obtained from the plans or measurements at the building.

Figs. 65 and 66 show the principles employed for obtaining the true angles and lengths in oblique piping, it being immaterial whether the piping is round, square, or oval in section. The only safe way in obtaining these angles is to use the center line as a basis and after this line has been obtained, build the pipe around it, so to speak. In Fig. 65 let A B C represent the elevation of the elbow shown in plan by D E. Through the center of the pipes draw the center line *a b c d* which intersect the center lines of the pipe in plan at *e* and *f*. In elevation the rise of the middle piece B on the center line is equal to *h c* and projects to the right a distance equal to *b h*, shown in plan by *e f*; this same pipe projects forward in plan a distance equal to *e a*. While the miter lines in elevation *i j*

and *k l* have been drawn straight, they would in reality show curved lines; those lines have not been projected as there is no necessity for doing so.

With the various heights and projections in plan and elevation the true length and true angles are obtained as shown in Fig.

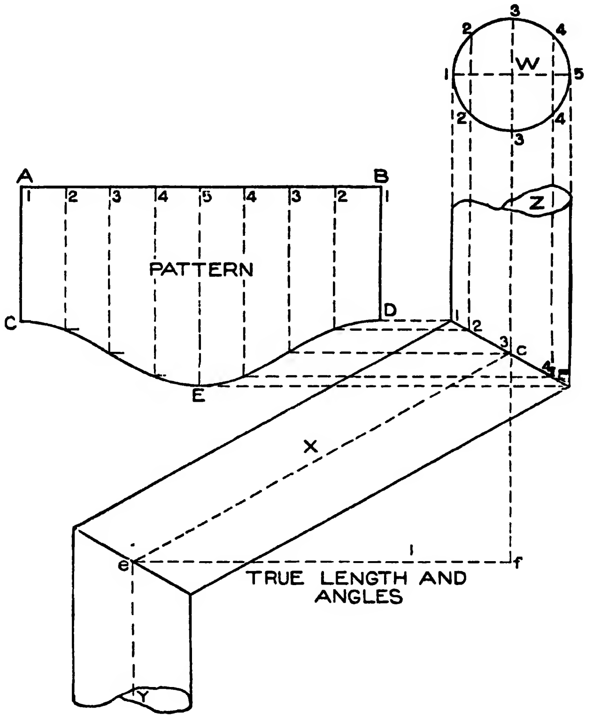


Fig. 66.

66, in which draw the horizontal line *e f* equal to *e f* in plan in Fig. 65. Take the height from *h* to *c* and place it from *f* to *c* in Fig. 66 on a vertical line erected from *f*. Draw a line from *e* to *c* which is the true length on the center line of the pipe shown by B in elevation in Fig. 65. From the points *c* and *e* in Fig. 66 draw perpendicular lines, making Y *e* X and X *c* Z = the true angles shown by *a b* X and X *c d* respectively in Fig. 65. On either side of the center line in Fig. 66 lay off the half diameter of the pipe as shown, and in its proper position draw the profile W.

Divide this into equal spaces and obtain the pattern A B D E C in the usual manner. As both angles are similar the miter cut C E D can be used for all of the patterns. In drawing this problem for practice make the diameter of the pipe 2 inches, the height from *h* to *c* 3¾ inches in Fig. 65, the projection *b* to *h* 3¾ inches, and the projection in plan *e* to *a* 5¼ inches.

Our next problem is that of a rain-water cut-off, a perspective view of which is shown in Fig. 67. While the miter cuts in this problem are similar to elbow work the intersection between the two beveled arms, and the cut-off or slide on the inside require attention. Make the diameter of the three openings each 2 inches; A to B (Fig. 68) 1½ inches. From B at an angle of 45° draw B C 3¼ inches and C D 2 inches. From G draw the vertical miter line G *h*. Make the distance from B to T ½ inch. Place the line *d e* of the cut-off ⅛ inch above the line T U as indicated at *a* and the line *e c* to the right of *h* G, as indicated by *b*, a distance of $\frac{3}{16}$ inch. Parallel to G H draw *c d* giving slight play room between G H, intersecting *e d* and *e c* at *d* and *c* respectively. From *e* at right angles to *d c*, draw a line as shown, intersecting *h* G at *f*, which is the pivot on which the cut-off *c d e* will turn either right or left. The angles of the pipes on opposite sides are constructed in similar manner; A B C D E F G H I J K L M will be the elevation, N, the section on A M and O P R S the section on I J. B T U L shows how far the upper tube projects into the body under which the scoop *e d c* turns right and left to throw the rain water into either elbow as desired. The pattern for the upper piece A T U M is a straight piece of metal whose circumference is equal to N.

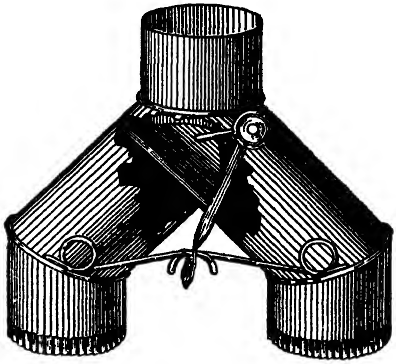


Fig. 67.

For the pattern for (A), divide the half section O P R into equal spaces as shown, from which erect lines intersecting the miter line H K as shown, and from which, parallel to K L and H G, draw lines intersecting the joint lines G *h* L as shown. As none of the

lines just drawn intersect the corner h, it will be necessary to obtain this point on the half section O P R from which the stretchout of the pattern is taken. Therefore from h, parallel to L K draw h h' intersecting H K at h', from which, parallel to K J, drop a line intersecting the profile O P R S at h''. At right angles to L K draw stretchout of O P R S as shown by similar numbers on T^1 U^1, through which at right angles to T^1 U^1 draw lines which are intersected by lines drawn at right angles to L K from similar in-

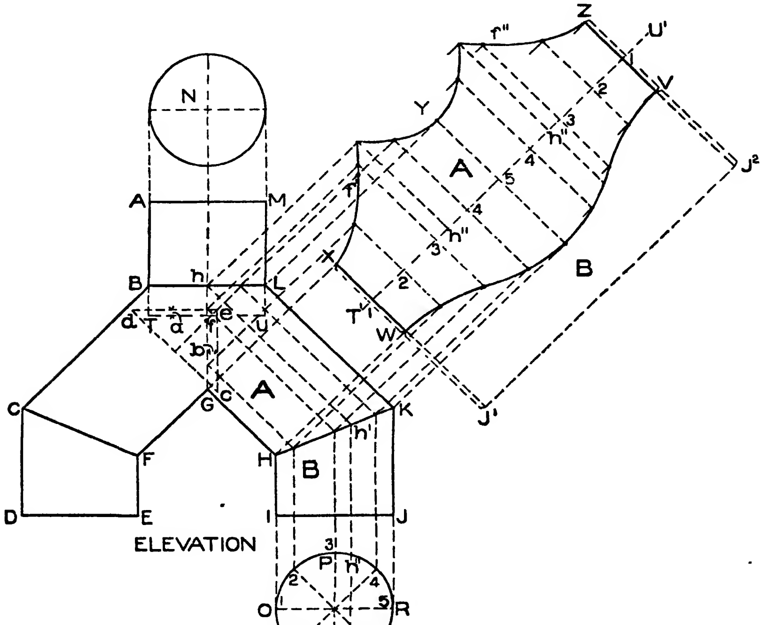


Fig. 68.

tersections on G h L and H K. A line traced through points thus obtained as shown by X Y Z V W will be the pattern for (A). From f in the elevation at right angles to L K project a line intersecting the miter cut X Y Z at f' and f''. At f' and f'' holes are to be punched in which the pivot f of the scoop c d e in elevation will turn.

While the pattern for (B) can be obtained as that for (A) was obtained, a short method is to take the distance K to J and place

it as shown from W to J^1 and V to J^2 on the lines of the pattern X W and Z V respectively extended. W V J^2 J^1 will be the pattern for B.

To avoid a confusion of lines in the development of the scoop or cut-off *c d e*, this has been shown in Fig. 69 in which *d e c* is a reproduction of *d e c* in Fig. 68. A true section of the scoop must now be drawn on *x e* in Fig. 69 so that its dimensions will allow it to turn easily inside of the joint line G *h* in elevation in Fig. 68. Therefore draw any horizontal line as 4 5 in Fig. 69, at right angles to which from *f* draw a vertical line intersecting 4 5 at *f*. Now take a distance $\frac{1}{16}$ inch less than one-half the diameter of O R in Fig. 68, and place it in Fig. 69 on either side of the line 4 5 on the vertical line just drawn as shown from *f* to 2 and *f* to 2′. Extend *d e* till it intersects 4 5 at 4. Draw a line from 4 to 2′; by bisecting this line we obtain the line *a b* intersecting 4 5 at *i*. Then with *i* as center and *i* 2′ as radius, describe the arc 2′ 2.

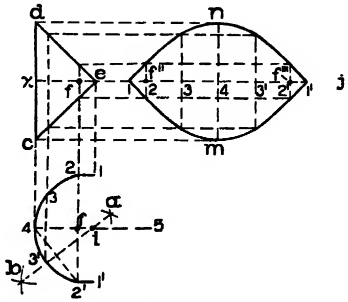


Fig. 69.

From 2 and 2′ draw horizontal lines equal to *f e* as shown by 2 1 and 2′ 1′. Then will 1 4 1′ be the true section on *x e*. Divide the half section into equal spaces as shown from 1 to 4, from which erect lines intersecting *c e* and *e d*. Extend *x e* as *x j*, upon which place the stretchout of 1 4 1′ as shown by similar numbers on *x j*, through which draw vertical lines. These lines intersect with horizontal lines drawn from similar intersections on *d e c*. Through points thus obtained draw the line 1 *n* 1′ *m* which is the desired pattern. As the pivot hole *f* falls directly on line 2, then *f‴ f″* will be the position of the holes in the pattern. Laps must be allowed to all patterns.

In putting up rectangular hot air pipe it is often the case that the pipe will be placed in the partition of one story, then has to fall forward and twist one quarter way around to enter the partition of the upper story which runs at right angles to the lower one. A perspective view showing this condition is shown in Fig. 70, where the upper opening turns one quarter on the lower one

and leaning to the right as much as is shown in Fig. 71 in plan. This problem is known as a transition piece in a rectangular pipe.

Full size measurements are given in Fig. 71 which should be drawn one-half size. The height of the transition piece is 1 foot 8 inches, the size of the openings, each 4×10 inches turned as shown, two inches to the left and two inches above the lower section as shown. From the plan construct the front and side elevations as shown by the dotted lines. A B C D and E F G H will then be the front and side elevations of the transition piece respectively

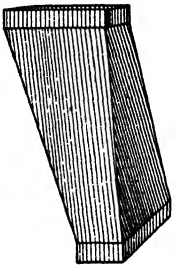


Fig. 70.

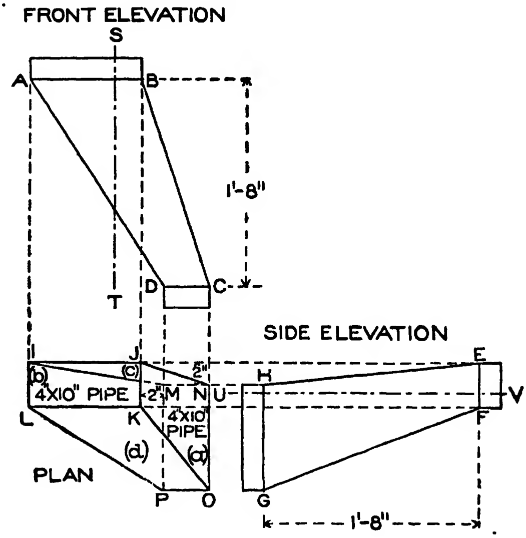


Fig. 71.

equal to 20 inches or 10 inches for practice. Number each side of the plan (*a*), (*b*), (*c*), and (*d*). Through the front and side elevations draw the vertical and horizontal lines S T and U V respectively at pleasure. These lines are only used as bases for measurements in determining the patterns. For the pattern for the side marked (a) in plan take the length of B C and place it on the vertical line B C in Fig. 72. Through the points B and C draw the horizontal lines E F and H G, making B F and B E, and C G and C H equal respectively to the distances measured from the line U V in Fig. 71 to points F, E, G, H. Draw lines from E to H and F to G in Fig. 72, which is the pattern for (a).

For the pattern for (b) in Fig. 71 take the distance of A D, and place it as shown by A D in Fig. 72; through A and D draw E F and H G, making A F and A E, and D G and D H equal

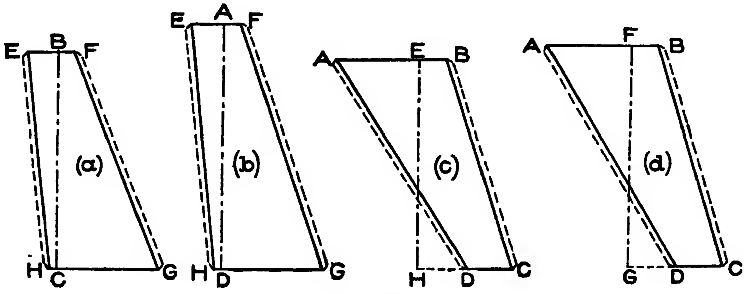


Fig. 72.

respectively to the distances measured from the line U V in side elevation in Fig. 71 to points F, E, G, H. Draw lines from E to H and F to G in Fig. 72, which will be the pattern for (b). In similar manner obtain the patterns for (c) and (d) in plan in Fig. 71. The lengths of E H and F G are placed as shown by similar letters

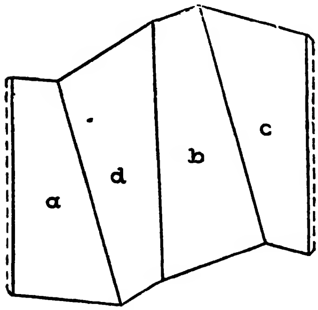


Fig. 73.

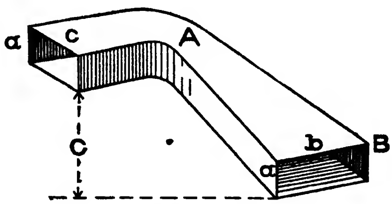


Fig. 74.

in Fig. 72, while the projections to A, B, C, D are obtained from A, B, C, D in front elevation in Fig. 71, measuring in each instance from S T.

If desired the top and lower flange shown in the perspective in Fig. 70 can be added to the patterns in Fig. 72. Laps are allowed to the patterns to allow for double seaming at corners, if, however, the pattern should be required in one piece, it would only

be necessary to join the various pieces in their proper positions as shown by *a d b c* in Fig. 73, which would bring the seam on the line J N in plan in Fig. 71.

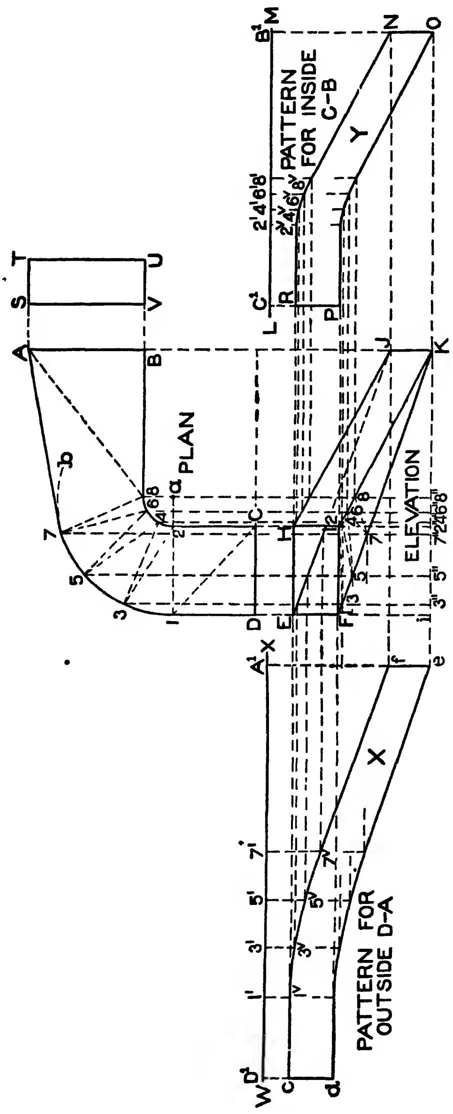
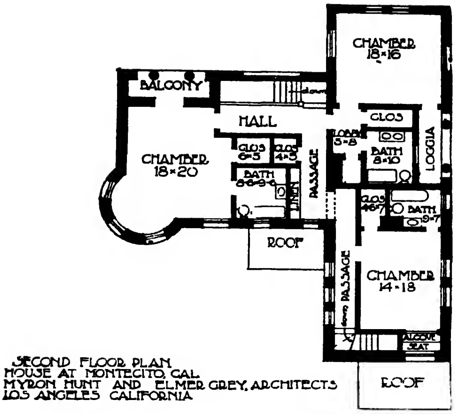
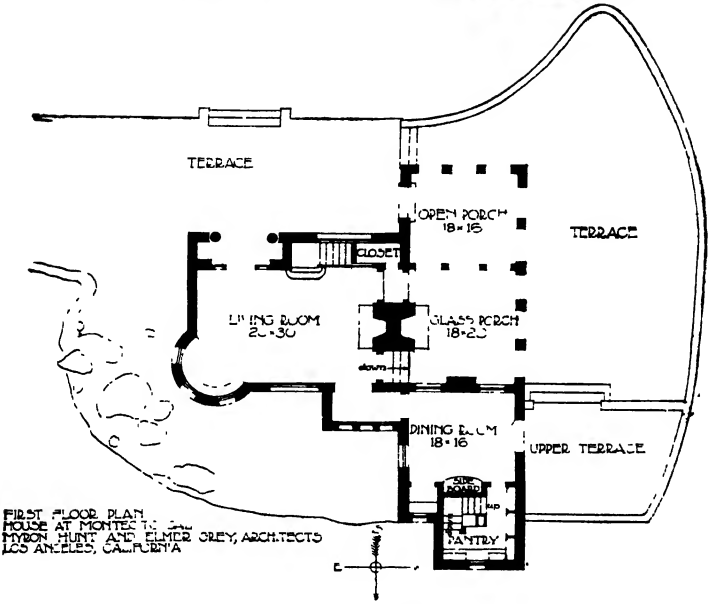
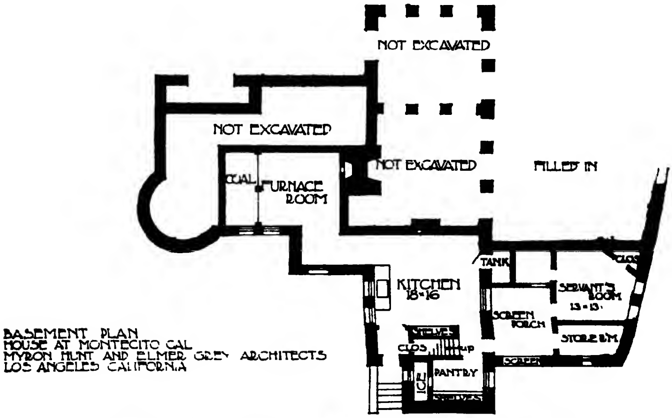


Fig. 75.

In Fig. 74 is shown a perspective view of a curved rectangular chute the construction of which arises in piping and blower work. The problem as here presented shows the sides *a* and *a* in vertical planes having the same height, while the bottom *b* has more width than the top *c*. The top opening is to rise above the bottom opening a given distance equal to C. First draw the plan and elevation as shown in Fig. 75, make A B equal to 2 inches, B 8 2½ inches; with a radius equal to ½ inch, with *a* as center draw the quarter circle 8 2. From 2 draw the vertical line 2 C equal to 1⅜ inches and draw C D equal to 1½ inches. Make D 1 equal to C 2 and using *a* as center and *a* 1 as radius draw the arc 1 *b*. From A draw a line tangent to 1 *b* as A 7. A B C D will be the plan of the chute. In line with A B draw the section S T U V. In line with D C draw the section E F I H as shown. Place the desired rise of the chute as shown by F *i* in elevation and from *i* draw a horizontal line as *i* K, which intersect by







PLANS OF HOUSE AT MONTECITO, CALIFORNIA

Myron Hunt & Elmer Grey, Architects, Los Angeles, Cal.

For Perspective View, See Page 138; for View of Terrace, See Page 186.

a line drawn from A B in plan as shown. Make K J equal to F E and draw the lines F K, K I, and E J, J H. F E J K is the elevation of the outside curve, H I K J the inside curve, F I K the bottom, and E H J the top.

Having the plan and elevation in position we will first draw the pattern for the two vertical sides. For the pattern for the side of the chute shown by B C in plan proceed as follows: Divide the inner curve 2 to 8 into equal parts as shown by 2-4-6 and 8, from which points drop lines intersecting the inside of the chute in plan H J K I as shown. At right angles to J K draw L M, upon which place the stretchout of B C in plan as shown by similar letters and numbers on L M, through which draw vertical lines which intersect lines drawn parallel to L M from H J. Through points thus obtained draw the line R 2^V 4^V 6^V 8^VN. The same method can

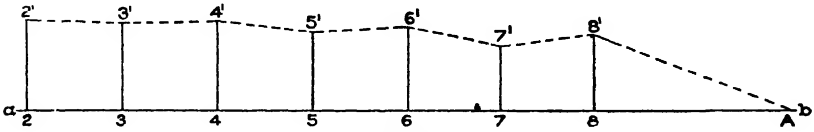


Fig. 76.

be employed for the curve P O, but as the height H I and J K are equal, having a common profile B C, take the height of H I or J K and place it on vertical lines as R P and N O and trace the curve R N as shown by P O. N O P R is the pattern for C B in plan; To obtain the pattern for the outside curve divide the curve 1-7 into equal parts as shown, from which drop vertical lines intersecting similar points in E J K F, in elevation at right angles to E F draw W X, upon which place the stretchout of D A in plan as shown. From the divisions on W X drop vertical lines, which intersect by lines drawn from similar numbered intersections on E J. Trace a line through these points as shown by *c f* and draw *d e* as explained in connection with the inside pattern. *c d e f* is the pattern for the outside of the chute shown in plan by D A.

As both the top and bottom of the chute have the same bevel, the pattern for one will answer for the other. Connect opposite points in plan as shown from C to 1 to 2 to 3 up to 8, then to A. In similar manner connect similar points on the bottom in elevation as shown from 1 to 2 up to K. The lines in plan represent

the bases of the sections whose altitudes are equal to the various heights in elevation, measured from *i* K. Take the various lengths from 2 to 3 to 4 to 5 to 6 to 7 to 8 to A in plan and place them as shown by similar numbers on the horizontal line *a b* (Fig. 76); through *a b* draw vertical lines, equal in height to similar numbers in elevation, in Fig. 75, measured from the line *i* K. For example take the distance 4 5 in plan and place it as shown by 4 5 in Fig. 76. Erect perpendiculars 4 4′ and 5 5′ equal to 4″ 4 and 5″ 5 in elevation in Fig. 75. Draw a line from 4′ to 5′ in Fig. 76, which is the true length of 4 5 in plan in Fig. 75. Proceed in similar manner for the balance of the sections. Take a tracing of 1 2 C D in plan and place it as shown by 1, 2, C, D in Fig. 77. Now using 1 as

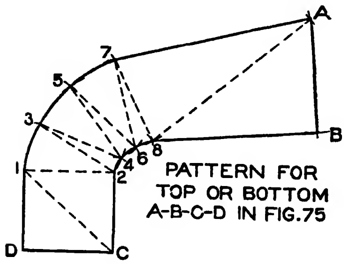


Fig. 77.

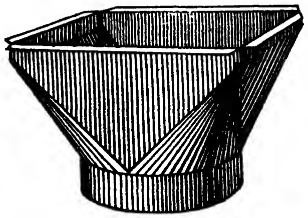


Fig. 78.

center and 1^V 3^V in (*x*), in Fig. 75, as radius, describe the arc at 3, in Fig. 77, which is intersected by an arc, struck from 2 as center, and 2′ 3′, in Fig. 76, as radius. Now with radius equal to 2^V 4^V in (Y) in Fig. 75 and 2 in Fig. 77 as center, describe the arc at 4 which is intersected by an arc, struck from 3 as center and 3′ 4′, Fig. 76, as radius. Proceed in this manner, using alternately as radius, first the divisions in the pattern (X), Fig. 75, then the slant lines in Fig. 76, the divisions in the pattern (Y), Fig. 75, then again the lines in Fig. 76 until the line 7 8, Fig. 77, has been obtained. Then using 7 as center, with a line equal to $7^V f$ in (X), Fig. 75, as radius, describe the arc A, Fig. 77, which is intersected by an arc struck from 8 as center and 8′ A, Fig. 76, as radius. Then with radius, equal to 8^V N in (Y), Fig. 75, and 8, Fig. 77, as center, describe the arc B, which is intersected by an arc, struck from A as center and A B in plan in Fig. 75 as radius. Trace lines through points thus obtained in Fig. 77,

and A B C D will be the desired pattern. Laps must be allowed on all patterns for double seaming the corners.

In Fig. 78 is shown a perspective view of a hopper register box usually made from bright tin or galvanized iron in hot air piping. In drawing this problem, the student should first draw the half plan, making the semicircle $3\frac{3}{4}$ inches diameter, and placing it directly in the center of the rectangular top, which is $3\frac{3}{4}$ inches wide and $5\frac{3}{4}$ inches long. Draw the elevation from the plan as shown by A B C D E F G H, making the vertical height V W, $2\frac{1}{4}$ inches, and the flanges at the top and bottom each $\frac{1}{2}$ inch. I K L M in plan is the horizontal section on A B in elevation and O P R the section on E F.

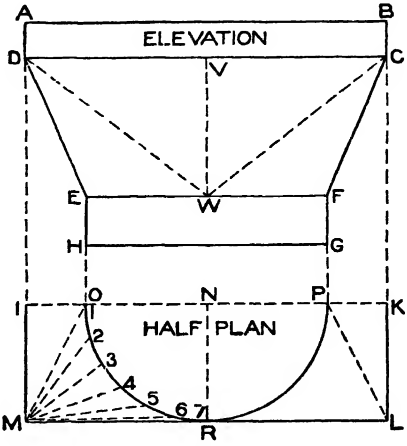


Fig. 79.

The pattern will be developed by triangulation, and the first step is to develop a set of triangles. Divide the quarter circle O R into equal spaces, as shown by the numbers 1 to 7 in plan, from which draw lines to the apex M. These lines represent the bases of triangles whose vertical height is equal to V W in elevation. Therefore, in Fig. 80, draw any horizontal line as T U, upon which place the various lengths M 1, M 2, M 3, etc.) Fig. 79) as shown by similar numbers on T U. From T U erect the line T S equal to the vertical height V W (Fig. 79). Then draw the hypotenuses S 1, S 2, S 3, etc., in Fig. 80, which represent the true lengths of similar numbered lines in plan in Fig. 79.

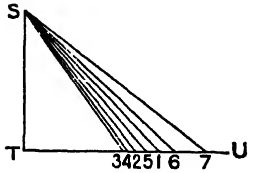


Fig. 80.

For the half pattern with seams on I O and P K in plan, take a tracing of D V W in elevation and place it as shown by D V 7 in Fig. 81. Now using D as center, and with radii equal to the various slant lines in Fig. 80 from S 1 to S 7 strike small arcs as shown from 1 to 7 in Fig. 81. Set the dividers

equal to the spaces contained in O R, in Fig. 79, and starting from point 7, in Fig. 81, step from one arc to another until 1 is obtained. Then using 1 as center and E D (Fig. 79) as radius describe the arc D′ in Fig. 81. With D as center and M I in plan in Fig.

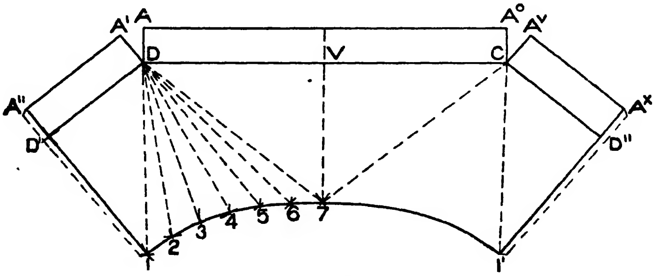


Fig. 81.

79 as radius, draw another arc intersecting the one previously drawn at D′. Draw a line from 1 to D′ to D in Fig. 81, 7 1 D′ D V is the quarter pattern, and the left-hand side of the figure may be made by tracing the quarter pattern reversed as shown by V C D″ 1′ 7. Take the distance of the flange D A in elevation in Fig. 79 and place it at right angles to the line D′ D, D C, C D″ as shown respectively by A″ A′, A A° and A^V A^X, which completes the half pattern with laps allowed as shown

The pattern for the collar E F G H in elevation in Fig. 79 is simply a straight strip of metal, equal to the circumference of O P R in plan.

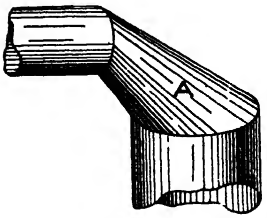


Fig. 82.

It is often the case that two unequal pipes are to be connected by means of a transition piece as shown by A in Fig. 82, the ends of the pipes being cut at right angles to each other. As the centers of both pipes are in one line when viewed in plan, making both halves of the transition piece equal, the problem then consists of developing a transition piece, from a round base to a round top placed vertically. Therefore in Fig. 83 draw 1 5 equal to $2\frac{1}{4}$ inches, and at an angle of 45° draw 5 6 $1\frac{3}{4}$ inches. At right angles to 1 5 draw 6 10 4 inches long and draw a line from 10 to 1. On 1 5 draw the semicircle 1 3′ 5, and on 6 10 draw the semicircle 6 8′ 10.

Divide both of these into equal spaces as shown, from which draw lines perpendicular to their respective base lines. Connect opposite points as shown by the dotted lines, and construct a diagram of

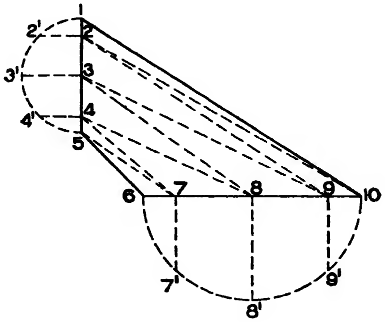


Fig. 83.

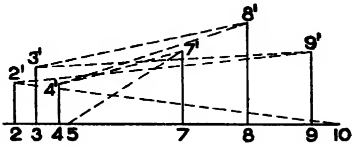


Fig. 84.

sections as shown in Fig. 84 whose bases and heights are equal to similar numbered bases and heights in Fig. 83. For example, take the distance 4 8 and place it as shown by 4 8 in Fig. 84, from which points erect the vertical lines 4 4′ and 8.8′ equal to 4 4′ and 8 8′ in Fig. 83. Draw a line from 4′ to 8′, Fig. 84, which is the true

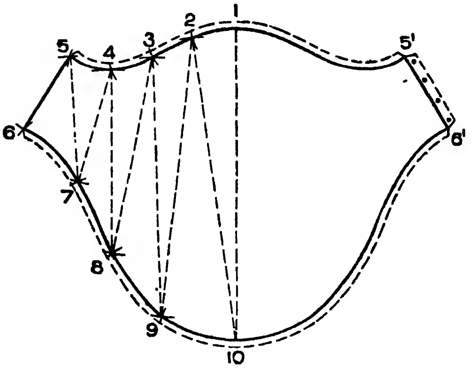


Fig. 85.

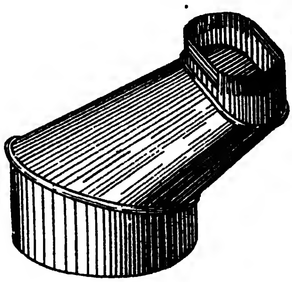


Fig. 86.

length on similar line in Fig. 83. For the pattern take the distance of 1 10 and place it as shown by 1 10 in Fig. 85. Using 1 as center, and 1 2′, Fig. 83, as radius, describe the arc 2 in Fig. 85; intersect it by an arc struck from 10 as center and 10 2′, Fig. 84, as radius. Then using 10 9′ in Fig. 83 as radius, and 10, Fig. 85, as

center, describe the arc 9, and intersect it by an arc struck from 2 as center, and 2′ 9′, Fig. 84, as radius. Proceed in this manner using alternately as radii, first the divisions in the half profile 1 3′ 5, Fig. 83, then the length of the proper hypotenuse in Fig. 84, then the divisions in 6 8′ 10 in Fig. 83; then again the hypotenuse in Fig. 84 until the line 5 6 in Fig. 85 has been obtained, which is equal to 5 6 in Fig. 83. Laps should be allowed for riveting and seaming as shown.

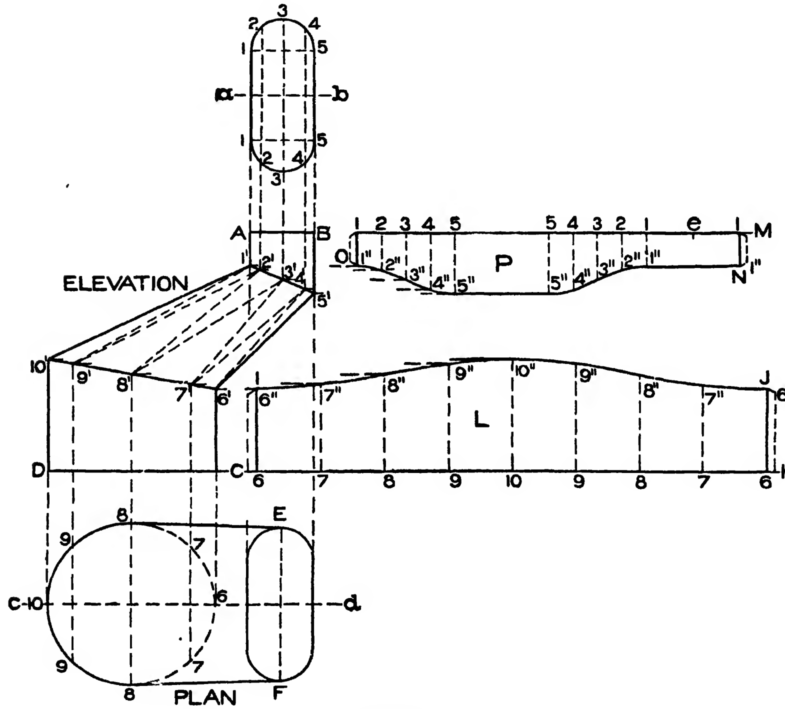


Fig. 87.

In Fig. 86 is shown a perspective of an offset connecting a round pipe with an oblong pipe, having rounded corners.

The first step is to properly draw the elevation and plan as shown in Fig. 87. Draw the horizontal line A B equal to one inch, B 5′ one inch, and from 5′ at an angle of 45° draw 5′ 6′ equal to $2\frac{1}{4}$ inches and 6′ C $1\frac{1}{4}$ inches. Make the diameter C D $2\frac{3}{4}$ inches and D 10′ $1\frac{3}{4}$ inches. Make A 1′ $\frac{1}{2}$ inch and draw a line from 1′ to

10′ which completes the elevation. Directly above the line A B draw the section of the oblong pipe, making the sides 1 1 and 5 5 equal to $1\frac{1}{2}$ inches, to which describe the semicircles on each end as shown. In similar manner draw the section on D C, which is shown by 6 8 10 8. A duplicate of the oblong pipe is also shown in plan by E F, showing that the centers of the pipe come in one line, making both halves symmetrical.

The patterns for the pipes will first be obtained. Divide the semicircular ends of the oblong section into equal parts, in this case four, also each of the semicircles of the round pipe in similar number of parts as shown respectively from 1 to 5 and 6 to 10. Draw vertical lines from these intersections cutting the miter line of the oblong pipe at 1′ 2′ 3′ 4′ 5′ and the miter line of the round pipe at 6′ 7′ 8′ 9′ and 10′. In line with A B draw B M, upon which place the stretchout of the oblong pipe as shown by similar numbers; from B M drop vertical lines intersecting the lines drawn parallel to B M from similarly numbered points on 1′ 5′. Trace a line through points thus obtained, and P N O will be the pattern for the oblong pipe. Now take the stretchout of the round pipe, and place it on C H; erect vertical lines as shown intersecting the lines drawn parallel to C H from similar intersections on 6′ 10′. I J H C is the pattern for the round pipe.

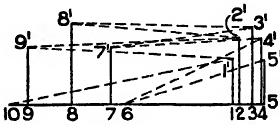


Fig. 88.

The transition piece 1′ 5′ 6′ 10′ will be developed by triangulation, and it is usual to obtain true sections on the lines 1′ 5′ and 6′ 10′; however, in this case it can be omitted because we have the true lengths of the various divisions on the lines 1′ 5′ and 6′ 10′ in the miter cuts in P and L respectively.

The next step is to obtain a diagram of sections giving the true lengths, for which proceed as follows: Connect opposite points in elevation as shown from 1′ to 9′ to 2′ to 8′ to 3′ etc., as shown. For example draw center lines through the oblong and round sections as shown by *a b* and *c d* respectively, and take the length of 1′ 10′ in elevation and place it as shown from 1 to 10 in Fig. 88. From 1 draw the vertical line 1 1′ equal to the height of 1 in the oblong section in Fig. 87 above the center line *a b*. As point 10 in plan has no height, it falls on the center line *c d* in plan, then

draw a line from 1′ to 10 in Fig. 88. Now take the distance from 1′ to 9′ in elevation, Fig. 87, and place it as shown from 1 to 9 in Fig. 88. Erect the lines 1 1′ and 9 9′ equal to points 1 and 9 in the oblong and round sections in Fig. 87, measured respectively from the lines *a b* and *c d*. Draw a line from 1′ to 9′ in Fig. 87. Proceed in this manner until all of the sections are obtained. For the pattern proceed as shown in Fig. 89, in which draw any vertical line as *e* 10 equal to 1′ 10′ in elevation in Fig. 87. Now, with one-half of 1 1 in pattern P as *e* 1 as radius, and *e* in Fig. 89 as center, describe the arc 1 which is intersected by an arc struck from 10 as center and 10 1′, in Fig. 88 as radius. With radius equal to 10″ 9″ in pattern L in Fig. 87, and 10 in Fig. 89 as center describe the arc 9, which is intersected by an arc struck from 1 as center and 1′ 9′, in Fig. 88 as radius. Now, using as radius 1″ 2″ in pattern P in Fig. 87 and 1 in Fig. 89 as center, describe the arc 2 which is intersected by an arc struck from 9 as center and 9′ 2′ in Fig. 88 as radius.

Proceed in this manner, using alternately as radii, first the divisions in the pattern cut I J, Fig. 87, then the length of the slant lines in Fig. 88, the divisions in the cut O N in Fig. 87, then again the slant lines in Fig. 88 until the line 5 6 in pattern, Fig. 89, has been obtained. Then using 5 as center and 1 *e* in P, Fig. 87, as radius, describe the arc *e*′ in Fig. 89, and intersect it by an arc struck from 6 as center and 6′ 5′ in elevation in Fig. 87 as radius. Draw lines through the various intersections in Fig. 89; 10 *e e*′ 6 is the half pattern. By tracing it opposite the line *e* 10, as shown by *e* 1′ 5′ *e*″ 6′ 10, the whole pattern, *e*′ *e e*″ 6′ 10 6, is found. Laps should be allowed on all patterns for seaming or riveting both in Figs. 87 and 89.

In Fig. 90 is shown a perspective view of a three-way branch round to round, the inlet A being a true circle, and the outlets B, C, and D also being true circles, the centers of which are in the same vertical plane, thus making both sides of the branch symmetrical.

First draw the elevation and the various sections as shown in Fig. 91. Draw the center line *a b*. From *b* draw the center line of the branch C at an angle of 58° as shown by *b d*. Make the center lines *a b* and *b d* each $3\frac{1}{2}$ inches long. Make the half diameter of the branch B at the outlet $\frac{3}{4}$ inch, and the full diam-

eter of the branch C at the outlet $1\frac{1}{2}$ inches placed on either side of and at right angles to the center lines. Draw a line from *e* to *f*, and with *i* and *h* as centers and radii equal to $\frac{3}{4}$ inch draw arcs intersecting each other at *c*. Draw lines from *i* to *c* to *h*. In similar manner obtain A and the opposite half of B. A B C is the elevation of the three branches whose sections on outlet lines are shown respectively by G F and E and whose section on the inlet line is shown by D.

The next step is to obtain a true section on the miter line or line of joint *b c*. Knowing the height *b c* and the width at the

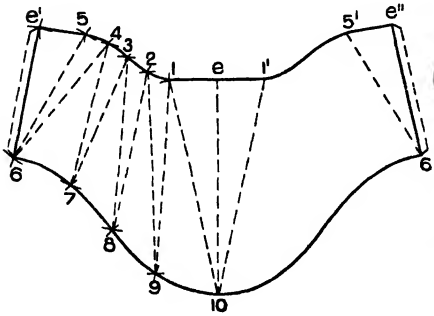


Fig. 89.

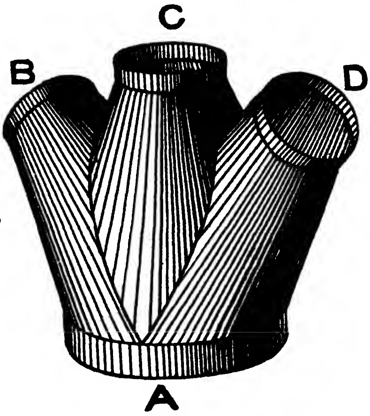


Fig. 90.

bottom, which is equal to the diameter of D, the shape can be drawn at pleasure as shown in Fig. 92, *b c* is drawn equal to *b c*, Fig. 91, while *b d* and *b a* are equal to the half diameter D in Fig. 91. Now through *a c d* in Fig. 92 draw the profile at pleasure as shown, which represents the true section on *c b* in Fig. 91.

As the side branches A and C are alike, only one pattern will be required, also a separate pattern for the center branch both of which will be developed by triangulation. To obtain the measurements for the sections for the center branch B, proceed as shown in Fig. 93 where 1 4 5 8 is a reproduction of one-half the branch B in Fig. 91. As the four quarters of this center branch are alike only one quarter pattern will be developed; then, if desired, the quarter patterns can be joined together, forming one pattern. Now

take a tracing of *c b a*, Fig. 92, and place it on the line 5 8 as shown in Fig. 93. Similarly take a tracing of the quarter profile F in Fig. 91 and place it on the line 4 1 in Fig. 93. Divide the two profiles 1′ 4 and 5 8′ each into the same number of spaces as shown respectively by points 1′ 2′ 3′ 4 and 5 6′ 7′ 8′, from which points at right angles to their respective base lines 1 4 and 5 8 draw lines intersecting the base lines at 1 2 3 4 and 5 6 7 8. Now draw solid lines from 3 to 6 and 2 to 7 and dotted lines from 3 to 5, 2 to 6, and 1 to 7. These solid and dotted lines represent

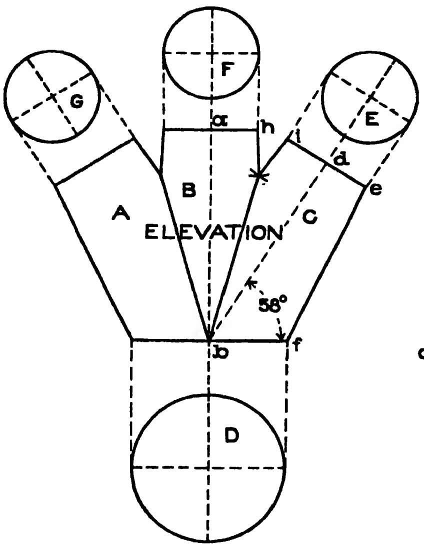


Fig. 91.

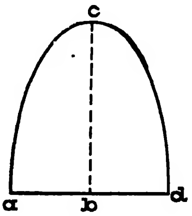


Fig. 92.

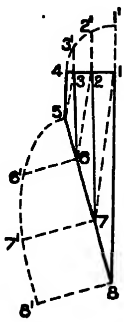


Fig. 93.

the bases of the sections whose altitudes are equal to the various heights of the profiles in Fig. 93. The slant lines in Fig. 94 represent the true distances on similar lines in Fig. 93, as those in Fig. 95 represent the true distances on dotted lines in Fig. 93.

For the pattern take the length of 1′ 8′, Fig. 94, and place it as shown by 1 8 in Fig. 96, and using 8 as center and 8′ 7′ in Fig. 93 as radius draw the arc 7, which intersect by an arc struck from 1 as center and 1′ 7′ in Fig. 95 as radius. Then using 1′ 2′ in Fig. 93 as radius draw the arc 2, which intersect by an arc struck from 7 as center and 7′ 2′ in Fig. 94 as radius. Proceed in this manner until the line 4 5 in Fig. 96 has been obtained

which equals 4 5 in Fig. 93. Trace a line through points thus obtained in Fig. 96, then will 1 4 5 8 1 give the quarter pattern.

If the pattern is desired in one piece trace as shown by similar figures, to which laps must be allowed for riveting.

As the two branches A and C in Fig. 91 are alike, one pattern will answer for the two. Therefore let 1 7 8 11 14 in Fig. 97 be a reproduction of the branch C in Fig. 91. Now take a tracing of *a b c* in Fig. 92 and place it as shown by 11′ 11 8 in Fig. 97; also take a tracing of the half section E and the quarter section D in Fig. 91 and place them as shown respectively by 1 4′ 7 and

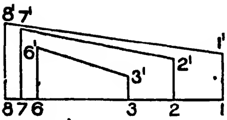


Fig. 94.

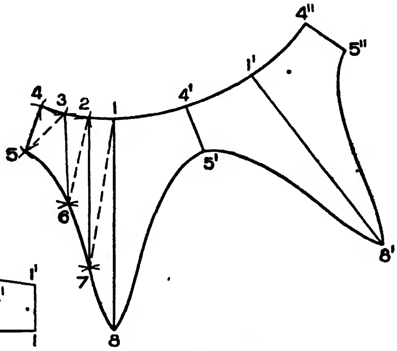


Fig. 96.

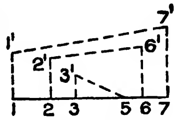


Fig. 95.

11 11′ 14 in Fig. 97. Now divide the two lower profiles 8 11 and 11′ 14 each into 3 equal parts, and the upper profile 7 4′ 1 into 6 equal parts as shown by the small figures 8 to 11′, 11′ to 14 and 1 to 7. From these points, at right angles to the various base lines, draw lines, intersecting the base lines as shown by similar numbers. Draw solid and dotted lines as shown, and construct the sections on solid lines as shown in Fig. 98 and the sections on dotted lines as shown in Fig. 99 in precisely the same manner as described in connection with Figs. 94 and 95.

In Fig. 100 is shown the pattern shape (to which laps must be allowed for riveting) obtained as was the development of Fig. 96. First draw the vertical line 1 14, Fig. 100, equal to 1 14 in Fig. 97. Then use alternately as radii, first the divisions in 1 4′ 7 in Fig. 97, the proper slant line in Figs. 98 and 99 and the divisions in 11′ 14 until the line 4 11, Fig. 100, is obtained. Starting from

the point 11 use as radii in their regular order the distances marked off between 11′ and 8, Fig. 97, then the proper slant lines in Figs. 98 and 99, the distances shown in the semicircle, 1 4′ 7, Fig. 97, until the line 7 8, Fig. 100, is drawn equal to 7 8, in Fig. 97. Then

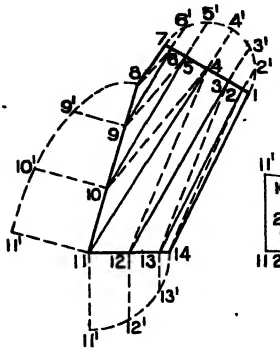


Fig. 97.

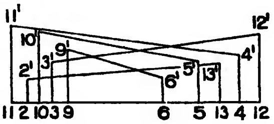


Fig. 98.

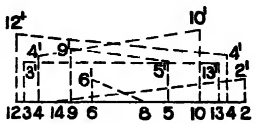


Fig. 99.

1 7 8 11 14, Fig. 100, will be the half pattern. If the pattern is desired in one piece trace 1 7′ 8′ 11′ 14 opposite the line 1 14 as shown.

In Fig. 101 is shown a perspective view of a two-branch fork oval to round, commonly used as breeching for two boilers. As

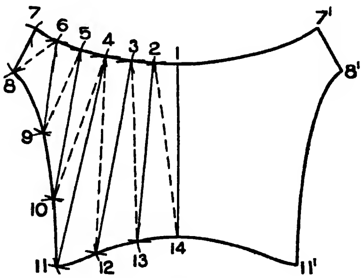


Fig. 100.

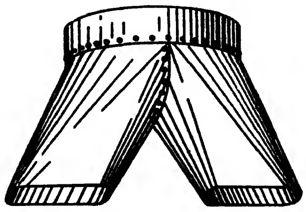


Fig. 101.

both halves of the fork are symmetrical the pattern for one will answer for the other.

While the side elevation shown in Fig. 102 is drawn complete, it is only necessary in practice, to draw one half as follows, and then, if desired, the other half elevation can be traced opposite

to the center line E J. First draw J B, $1\frac{1}{2}$ inches, equal to the half diameter of the outlet, and the vertical center height J V, $2\frac{1}{4}$ inches. Establish the height of the joint J E one inch, and the desired projection V D on the base line $1\frac{1}{4}$ inches. Draw the length of the inlet D C $2\frac{3}{4}$ inches, and draw a line from C to B and D to E. Draw a similar figure opposite the line J E, and A B C D E F G shows the side elevation of the fork. In their proper position below A B draw the sections M and N whose semicircular ends are struck from *a b c* and *d* with radii equal to $\frac{1}{2}$ inch. Now draw an end elevation in which the true section on

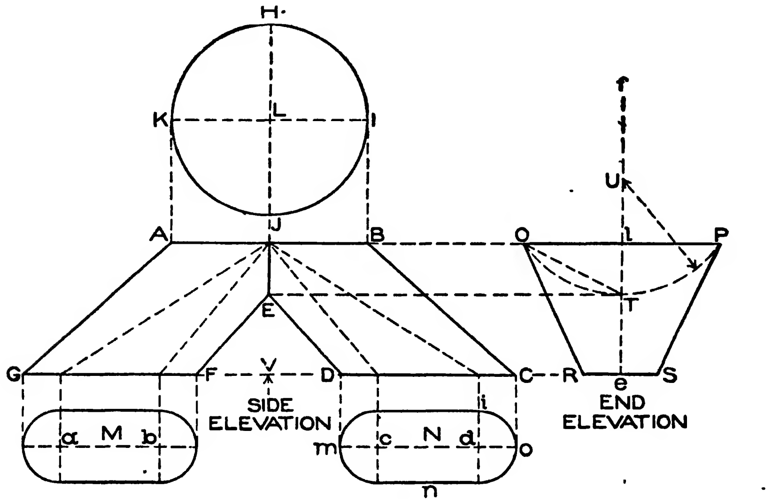


Fig. 102.

J E is obtained. Draw the center line *f e* and extend the lines A B and G C in elevation as A P and G S. Take the half diameter L J and place it on either side of *e f* as shown by O P. In a similar manner take the half diameter of the section N as *d i* and place it on either side of *e f* as shown by R S. Then O P S R shows the end elevation. Draw E T intersecting *e f* at T. Now draw the curve O T P, which in this case is struck from the center U, being obtained by bisecting the line O T. It should be understood that the curve O T P, which represents the true section on J E, can be made any desired shape, but when once drawn, represents a fixed line.

The pattern will be developed by triangulation, for which diagrams of sections must be obtained from which to obtain measurements. These sections are obtained as follows: In Fig. 103 1 4 5 12 13 is a reproduction of J B C D E, Fig. 102. Reproduce the quarter profile H L I, the half profile O T, and the half profile *m n o* as shown by 1′ 1 4, 1″ 13 1 and 12 9′ 8′ 5 in Fig. 103. Divide the round ends in *a* each into 3 parts and the profiles *b* and *c* also each into 3 spaces, as shown by the figures. Drop lines from these figures at right angles to the base lines from 1 to 15 as shown and draw solid and dotted lines in the usual manner. While in some of the previous problems only dotted lines were drawn, we

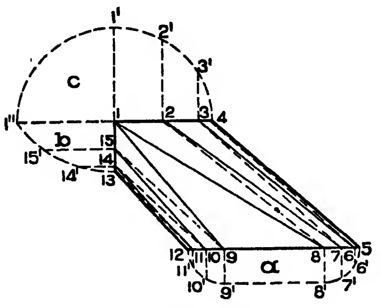


Fig. 103.

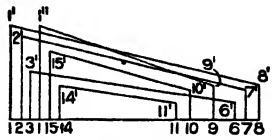


Fig. 104.

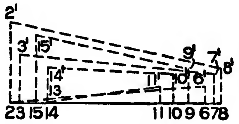


Fig. 105.

have drawn both solid and dotted lines in this case, in order to avoid a confusion of sections. A diagram of sections on solid lines in Fig. 103 is shown in Fig. 104, the figures in both corresponding; while Fig. 105 shows the true sections on dotted lines. The method of obtaining these sections has been described in connection with other problems.

For the pattern draw any vertical line as 4 5, Fig. 106, equal to 4 5 in Fig. 103. Then with 5 6′, Fig. 103, as radius and 5 in Fig. 106 as center draw the arc 6, intersecting it by an arc struck from 4 as center and 4 6′, Fig. 105, as radius. Then using 4 3′, Fig. 103, as radius, and 4 in Fig. 106 as center, describe the arc 3, intersecting it by an arc struck from 6 as center and 6′ 3′ in Fig. 104 as radius. Proceed in this manner, using alternately as radii, first the divisions in *a* in Fig. 103, then the slant lines in Fig. 105; the divisions in *c* in Fig. 103, then the slant lines in Fig.

104, until the line 1 8, Fig. 106, is obtained. Now using 8 as center and 8′ 9′, Fig. 103, as radius draw the arc 9 in Fig. 106, intersecting it by an arc struck from 1 as center and 1″ 9′, Fig. 104, as radius. Then starting at 1 in Fig. 106 use alternately as radii, first the divisions in *b* in Fig. 103, then the slant lines in Fig. 105, the divisions in *a* in Fig. 103, then the length of the slant lines in Fig. 104 until the line 12 13 is obtained in Fig. 106, which equals 12 13 in Fig. 103. Trace a line through points thus obtained in Fig. 106, then will 4 1 13 12 9 8 5 be the half pattern. If the pattern is desired in one piece, trace this half opposite the line 4 5 as shown by 1′ 13′ 12′ 9′ 8′, allowing laps for riveting.

In Fig. 107 is shown a perspective view of a tapering flange around a cylinder passing through an inclined roof, the flange

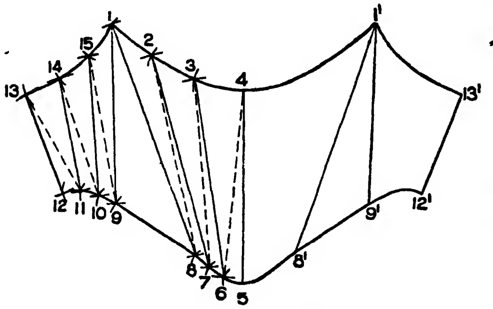


Fig. 106.

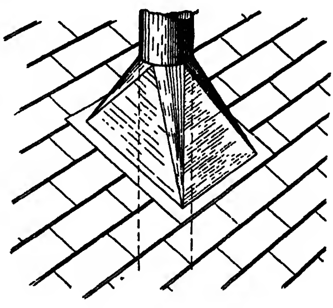


Fig. 107.

being rectangular on the roof line. The problem will be developed by triangulation, a plan and elevation first being required as shown in Fig. 108.

First draw the angle of the roof A B at an angle of 45°, through which draw a center line C D. From the roof line A B on the center line set off *a b* equal to 4 inches and through *b* draw the horizontal line E F, making B F and B E each one inch. Through *d* on the center line draw the horizontal line G H, making *d* H and *d* G each two inches. From H and G erect perpendiculars intersecting the roof line at K and L. Then draw lines from E to K and F to L, completing the elevation. Construct the square in plan making the four sides equal to G H. Bisect H I and draw the center line *c e* intersecting the vertical center at *d*′. Then with radius equal to *b* F or *b* E in elevation and *d*′ in plan as center,

draw the circle 1 4 7 4′ representing the horizontal section on E F in elevation, while G H I J is the horizontal section on K L in elevation. As the circle in plan is in the center of the square making the two halves symmetrical it is only necessary to divide the semicircle into equal spaces as shown from 1 to 7 and draw lines

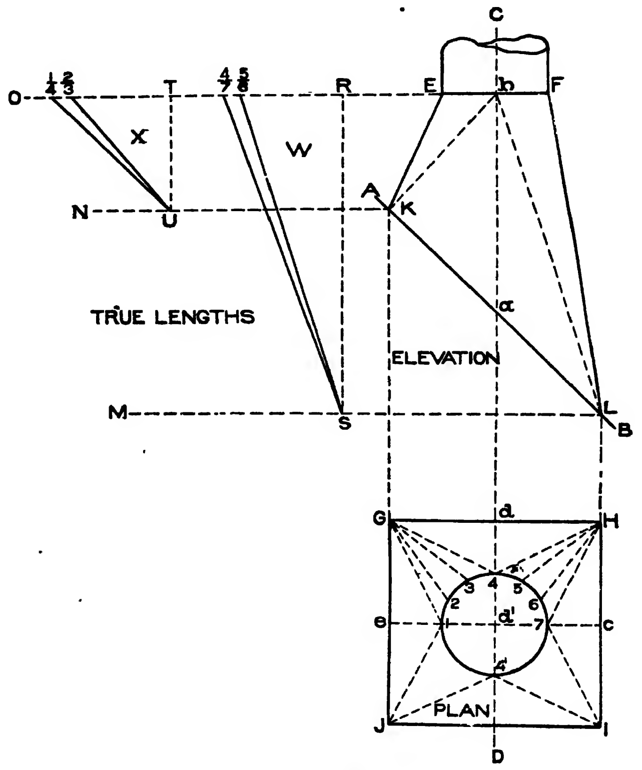
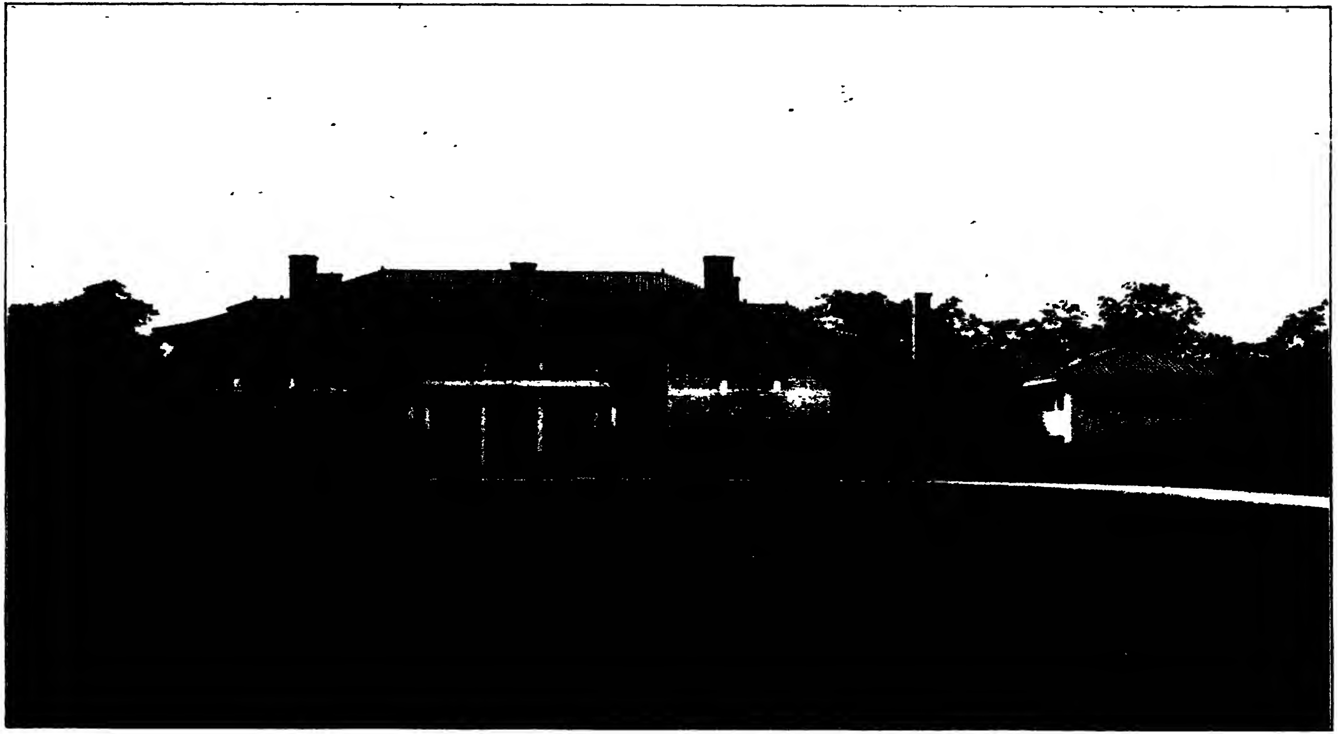
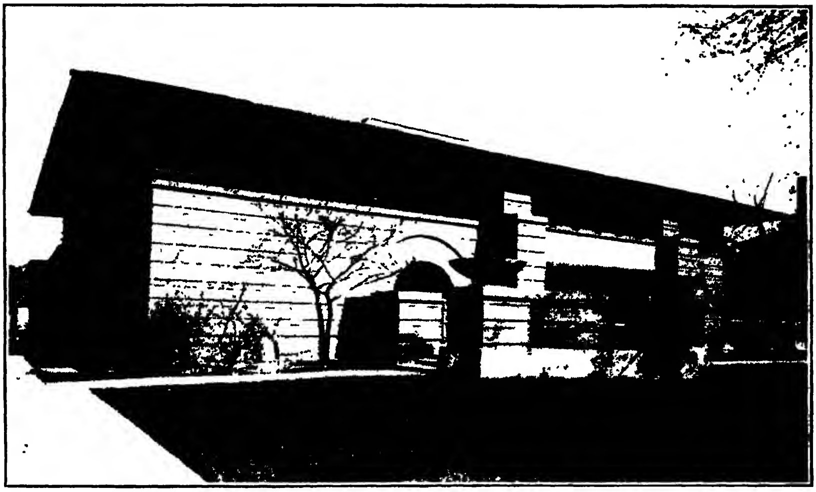


Fig. 108.

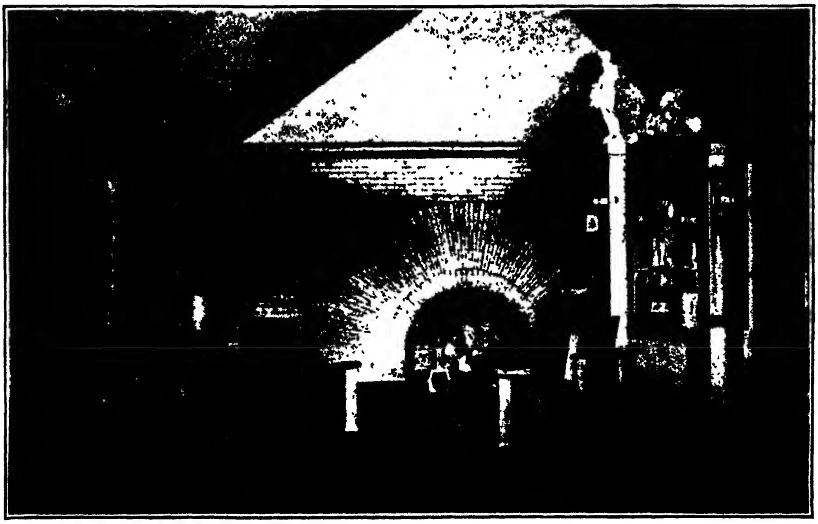
from 1, 2, 3 and 4 to G, and 4, 5, 6 and 7 to H. Then will the lines in 1 G 4 and 4 H 7 represent the bases of triangles which will be constructed, whose altitudes are shown respectively by the vertical heights in K E and L F in elevation. Therefore draw horizontal lines through E F, K, and L as shown by F O, K N, and L M. From any point as R and T on F O, draw the perpendiculars R S and T U respectively, meeting the horizontal lines drawn from L and K. Now take the various lengths in plan as G1, G2, G3, and



RESIDENCE OF B. J. ALLAN, BEVERLY, MASS.
Guy Lowell, Architect, Boston, Mass.
Red Spanish Tile Roofs
Reproduced by Courtesy of Ludovici-Celadon Company.



Exterior View



Living Room

RESIDENCE OF MR. ARTHUR HEURTLEY, FOREST AVENUE, OAK PARK, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.

Walls of Brick, Salmon Color; Roof of Shingles. Cost, $14,000. A Strong and Unique Treatment of a Residence Design.

G4 and place them on the line F O as shown by T1, T2, T3 and T4, from which points draw lines to U which will represent the true lengths on similar lines in plan. In similar manner take the distances in plan from H to 4, to 5, to 6, to 7, and place them on the line F O, from R to 4, to 5, to 6, to 7, from which points draw lines to S which represent the true lengths on similar lines in plan.

For the pattern take the distance F L in elevation and place it on the vertical line 7′ L in Fig. 109. At right angles to 7′ L draw L S equal to *c* H or *c* I in plan, Fig. 108. Draw the dotted

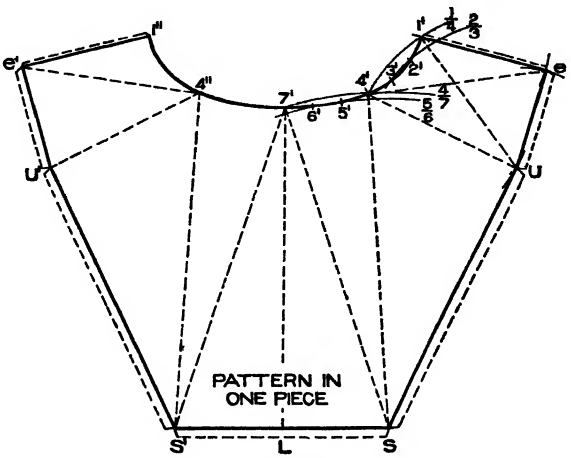


Fig. 109.

line from 7′ to S in Fig. 109, which should be equal to S 7 in W in Fig. 108. Now with radii equal to S $\frac{4}{7}$, and S $\frac{5}{6}$ and S, Fig. 109, as center, draw the arcs indicated by similar numbers. The dividers should equal the spaces in the semicircle in plan in Fig. 108, and starting at 7′ in Fig. 109, step from arc to arc of corresponding numbers as shown by 6′, 5′, 4′. Draw a dotted line from 4′ to S. Then using S as center and L K in elevation, Fig. 108, as radius, describe the arc U in Fig. 109, intersecting it by an arc struck from 4′ as center and U 4, Fig. 108, as radius. Now using U $\frac{1}{4}$, and U $\frac{2}{3}$ in X as radii, and U, Fig. 109, as center, describe arcs having similar numbers. Again set the dividers equal to the spaces in plan in Fig. 108, and starting from 4′ in Fig. 109 step to corresponding numbered arcs as shown by 3′, 2′, 1′.

Draw a dotted line from 4′ to U to 1′. With K E in elevation, Fig. 108, as radius, and 1′ in Fig. 109 as center, describe the arc *e* intersecting it by an arc struck from U as center and G *e* in plan in Fig. 108 as radius. Draw a line connecting S, U, *e*, and 1′. 7′ 4′ 1′ *e* U S L 7′ shows the half pattern, which can be traced opposite the line 7′ L to complete the full pattern as shown by 7′ 4″ 1″ *e*′ U′ S′ L.

One of the difficult problems often encountered by the sheet metal worker is that of a cylinder joining a cone furnace top at any angle. The following problem shows the principle to be applied, no matter what size the furnace top has, or what size pipe is used, or at what angle the pipe is placed in plan or elevation, the principles being applicable under any conditions.

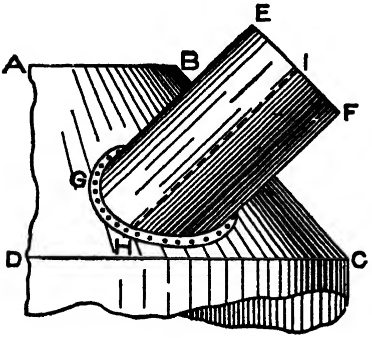


Fig. 110.

Fig. 110 shows a view of a cylinder intersecting a conical furnace top, the top being placed to one side of the center of the top. A B C D represents a portion of the conical top, intersected by the cylinder E F G H, the side of the cylinder H I to intersect at a given point on the conical top as at H. This problem presents an interesting study in projections, intersections, and development, to which close attention should be given.

In Fig. 111 first draw the center line A X. Then draw the half elevation A B C D, making A B $1\frac{5}{8}$ inches, C D $3\frac{1}{2}$ inches and the vertical height A D $2\frac{1}{8}$ inches. Draw the line from B to C. Directly below C D draw the one-quarter plan using Z as center, as shown by Z C^1 D^1 and in line with A B of the elevation draw the quarter plan of the top as Z B^1 A^1. Let *a* in the elevation represent the desired distance that the side of the cylinder is to meet the cone above the base line as H in Fig. 110. From *a*, parallel to C D in Fig. 111, draw *a b*. Then from *a* drop a vertical line intersecting the line Z C^1 in plan at *a*′. Then using Z as center and Z *a*′ as radius, describe the quarter circle *a*′ *b*′. Z *a*′ *b*′

in plan represents the true section on the horizontal plane a b in elevation. Now locate the point where the side of the cylinder as H in Fig. 110 shall meet the arc a' b' in plan, Fig. 111, as shown

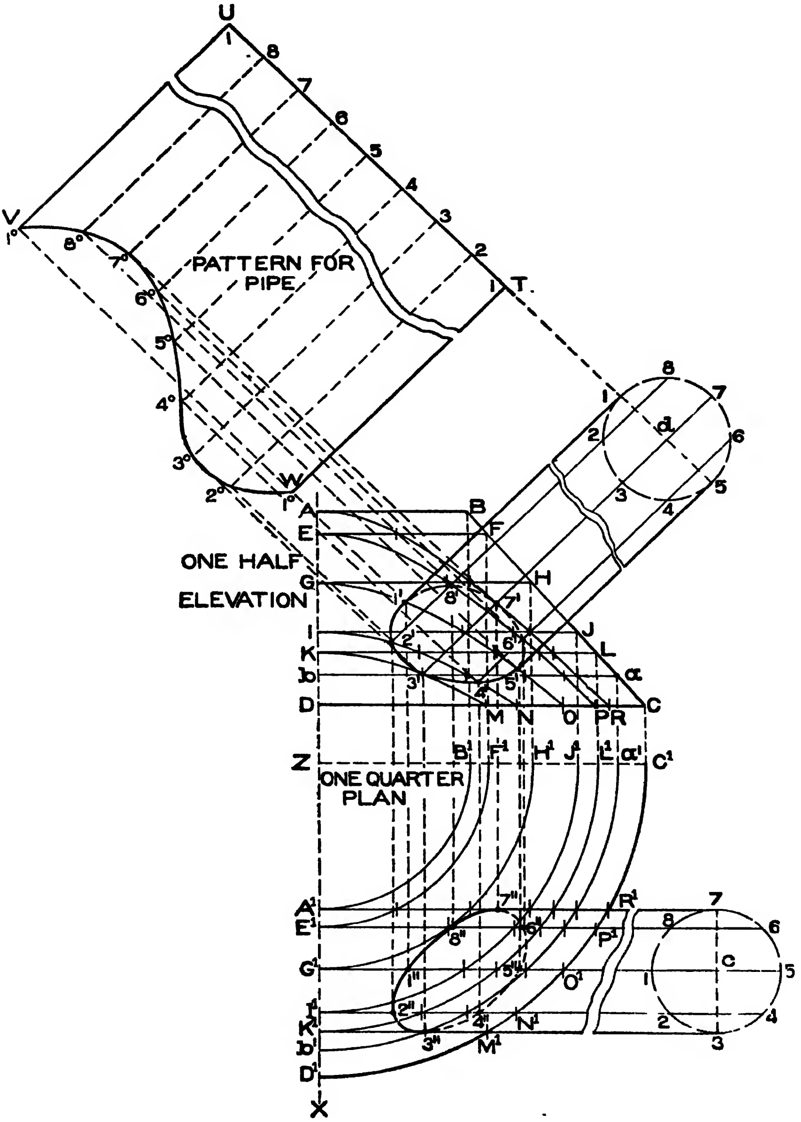


Fig. 111.

at 3″. Through 3″ draw the horizontal line intersecting the center line at K^1, the outer arc at M^1 and extend it indefinitely to 3. From 3 erect the perpendicular equal to the diameter of the cylinder, or $1\frac{5}{8}$ inches, bisect it and obtain the center *c*. Using *c* as center with *c* 7 as radius, describe the profile of the cylinder as shown, and divide it into equal parts from 1 to 8. From these points draw lines parallel to 3 K^1, intersecting the outer arc D^1 C^1 at N^1 O^1 P^1 R^1 and the center line Z X at I^1, G^1, E^1, A^1. With Z as center and the various intersections from K^1 to A^1 as radii, describe the arcs K^1 L^1, I^1 J^1, G^1 H^1, E^1 F^1, and A^1 B^1. From the intersection B^1, F^1, H^1, J^1, L^1 erect vertical lines into the elevation intersecting the side of the cone B C as shown by similar letters B F H J L. From these points draw horizontal lines through the elevation as shown respectively by A B, E F, G H, I J, and K L. These lines represent a series of horizontal planes, shown in plan by similar letters. For example, the arc E^1 F^1 in plan represents the true section on the line E F in elevation, while the arc G^1 H^1 is the true section on the line G H in elevation, etc.

The next step is to construct sections of the cone as it would appear, if cut by the lines shown in plan by K^1 M^1, I^1 N^1, G^1 O^1, E^1 P^1, and A^1 R^1. To obtain the section of the cone in elevation on the line A^1 R^1 in plan, proceed as follows: At right angles to the line A^1 R^1 and from the intersections on the various arcs, draw lines upward (not shown) intersecting similar planes in elevation corresponding to the arcs in plan. A line traced through intersections thus obtained in elevation as shown from A to R, will be the true section on the line A^1 R^1 in plan. For example, the line K^1 M^1 of the cylinder intersects the arcs at K^1 3″ and M^1 respectively. From these intersections, erect vertical lines intersecting K L, *b a*, and D C in elevation at K, 3′, and M respectively. Trace a curve through these points, then will K 3′ M be the section of the cone if cut on the line K^1 M^1 in plan. In similar manner obtain the other sections. Thus the section line E P, G O, and I N in elevation, represent respectively the sections if cut on the lines E^1 P^1, G^1 O^1, and I^1 N^1 in plan. Now from the given point 3″ in plan erect a line which must meet the intersection of the plane *b a* and section K M in elevation at 3′. From 3′ at its desired angle, in this case 45°, draw the line 3′ 7. At any point as *d* at right angles to 3′ 7 draw the

line 1 5 through *d*, making *d* 5 and *d* 1 each equal to half the diameter of the cylinder shown in plan. With *d* 5 as radius and *d* as center draw the profile of the cylinder in elevation, and divide it into the same number of parts as shown in C in plan, being careful to allow the circle *d* in elevation to make a quarter turn, bringing the number 1 to the top as shown.

The next operation is to obtain the miter line or line of joint between the cylinder and cone in elevation. By referring to the plan it will be seen that the point 7 in the profile *c* lies in the plane of the section A^1 R^1. Then a line from the point 7 in the profile *d* in elevation, drawn parallel to the lines of the cylinder, must cut the section A R which corresponds to the plane A^1 R^1 in plan as shown by 7′ in elevation. The points 6 and 8 in the profile *c* in plan, are in the plane at the section E^1 P^1, then must the corresponding points 6 and 8 in the profile *d* in elevation, intersect the section E P as shown by 6′ and 8′. As the points 1 5, 2 4, and 3 in the profile *c* in plan, are in the planes of the sections G^1 O^1, I^1 N^1, and K^1 M^1 respectively, the corresponding points 1 5, 2 4, and 3 in the profile *d* in elevation must intersect the sections G O, I N, and K M respectively at points 1′ 5′, 2′ 4′, and 3′ as shown. Trace a line through these points, which will show the line of intersection between the cone and cylinder.

For the pattern for the cylinder, proceed as follows: At right angles to the line of the cylinder in elevation, draw the line T U upon which place the stretchout of the profile *d* as shown by similar figures on T U. In this case the seam of the pipe has been placed at 1 in *d*. Should the seam be desired at 3, 5 or 7, lay off the stretchout on T U starting with any of the given numbers. At right angles to U T from the small figures 1 to 1 draw lines which intersect with lines drawn from similar numbered intersections in the miter line in elevation at right angles to 1′ 1, resulting in the intersections 1 to 5° to 1° in the pattern. Trace a line through points thus obtained, then will U V W T be the development for the cylinder to which laps must be allowed for riveting to the cone as shown in Fig. 110 and seaming the joint T W in pattern in Fig. 111.

While the pattern for the cone is obtained the same as in ordinary flaring ware, the method will be described for obtaining

the pattern for the opening to be cut into the cone. Before this can be done a plan view of the intersection between the pipe and cone must first be obtained as follows: From the various intersections $1'$ to $8'$ in elevation drop vertical lines intersecting lines drawn from similar numbers in the profile *c* in plan, thus obtaining the intersections $1''$ to $8''$ through which a line is traced which is the desired plan view.

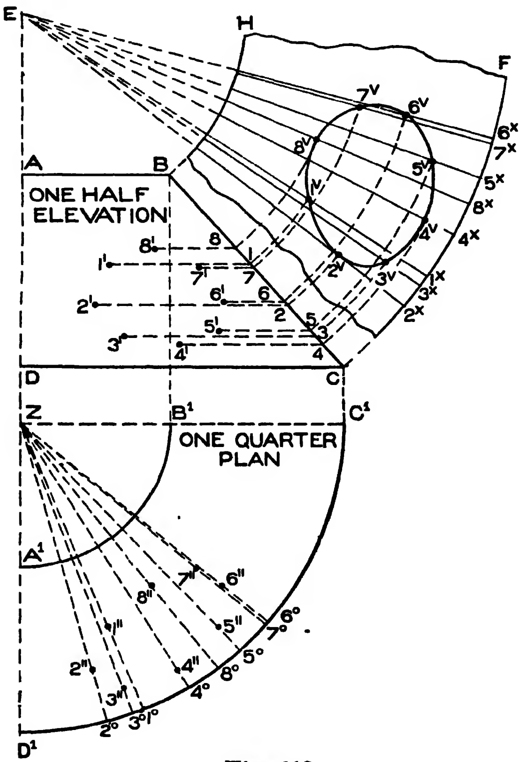


Fig. 112.

For the pattern for the opening in the cone, the outline of the half elevation and one-quarter plan with the various points of intersections both in plan and elevation in Fig. 112 is a reproduction of similar parts in Fig. 111, and has been transferred to avoid a confusion of lines which would otherwise occur in obtaining the pattern. Parallel to D C in Fig. 112 from the various intersections $1'$ to $8'$ draw lines intersecting the side of the cone B C from 1 to 8. Through the various intersections $1''$ to $8''$ in plan from the apex Z draw lines intersecting the outer curve from 1° to 8° as shown. Extend the line C B in elevation until it meets the center line D A extended at E. Then using E as center, with E C and E B as radii draw the arcs C F and B H respectively. At any point as 2^x on the arc C F lay off the stretchout of the various points on D^1 C^1 in plan from 2° to 6° as shown by similar figures on C F as shown

from 2^x to 6^x. From these points draw radial lines to the apex E, and intersect them by arcs struck from E as center whose radii are equal to the various intersections on B C having similar numbers. Thus arc 4 intersects radial line 4^x at 4^v; arcs 3, 5, and 2 intersect radial lines 3^x, 5^x, and 2^x at 3^v, 5^v, and 2^v, and so on. Trace a line through points thus obtained as shown from 1^v to 8^v which is the desired shape. If a flange is desired to connect with the cylinder, a lap must be allowed along the inside of the pattern.

COPPERSMITH'S PROBLEMS.

In the five problems which will follow, particular attention is given to problems arising in the coppersmith's trade. While all the previous problems given in the course can be used by the coppersmith in the development of the patterns where similar shapes are desired, the copper worker, as a rule, deals mostly with hammered surfaces, for which flaring patterns are required. The principles which will follow, for obtaining the blanks or patterns for the various pieces to be hammered, are applicable to any size or shape of raised work. The copper worker's largest work occurs in the form of brewing kettles, which are made in various shapes, to suit the designs of the different architects who design the work. In hammering large brewing kettles of heavy copper plate, the pieces are developed, hammered, and fitted in the shop, then set together in the building, rope and tackle being used to handle the various sections for hammering, as well as in construction at the building. While much depends upon the skill the workman has with the hammer, still more depends upon the technical knowledge in laying out the patterns.

In all work of this kind the patterns are but approximate, but no matter what size or shape the work has, the principles contained in the following problems are applicable to all conditions.

In Fig. 113 is shown a perspective of a sphere which is to be constructed of horizontal sections as shown in Fig. 114, in which for practice draw the center line A B, on which, using a as center, and with radius equal to $2\frac{1}{4}$ inches, describe the elevation of the sphere B C D E. Divide the quarter circle D C into as many spaces as the hemi-sphere is to have sections, as shown by C F G D. From these points draw horizontal lines through the elevation, as

shown by C E, F H, and G I. Now through the extreme points as E H, H I, and I D draw lines intersecting the center line B A at J, K, and D respectively. For the pattern for the first section Z, take D I as radius, and using D^1 in Z^1 as center, describe the circle shown. For the pattern for the second section Y, use K I and K H as radii, and with K^1 as center draw the arcs I^1 I^2 and H^2

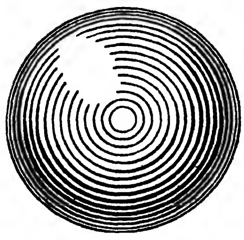


Fig. 113.

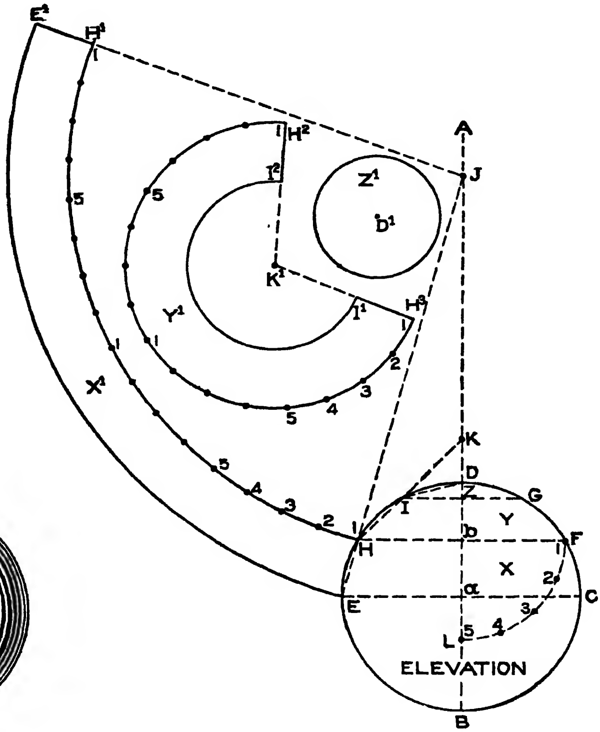


Fig. 114.

H^3. From any point as H^3 draw a line to the center K^1. It now becomes necessary to draw a section, from which the true length of the patterns can be obtained. Therefore with *b* F as radius, describe the quarter circle F L, which divide into equal spaces, as shown by the figures 1 to 5. Let the dividers be equal to one of those spaces and starting at H^3 on the *outer arc* in Y^1 step off four times the amount contained in the quarter section F L, as shown from 1

to 5 to 1 to 5 to 1 in Y^1. From 1 or H^2 draw a line to K^1. Then will H^2 I^2 I^1 H^3 be the pattern for the section Y in elevation.

For the pattern for the third section, use J as center, and with radii equal to J H and J E draw the arcs H H^1 and E E^1. Now set the dividers equal to one of the equal spaces in F L and starting from H set off four times the amount of L F as shown from 1 to 5 to 1 to 5 to 1 on the *inner curve* H H^1. From the apex J through H^1 draw a line intersecting the outer curve at E^1. E E^1 H^1 H shows the pattern for the center section. It will be noticed in the pattern X^1 we space off on the inner curve, while on the pattern Y^1 we space off on the outer curve. These two curves must contain the same amount of material as they join together when the ball is raised. To all of the patterns laps must be allowed for brazing or soldering. The patterns shown are in one piece; in practice where the sphere is large they are made in a number of sections.

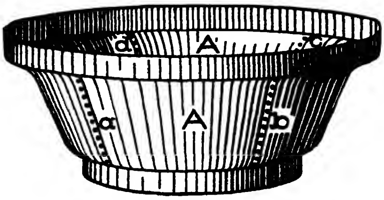


Fig. 115.

In Fig. 115 is shown the perspective view of a circular tank whose outline is in the form of an ogee. The portion for which the patterns will be described is indicated by A A, made in four sections, and riveted as shown by *a b c d*.

Fig. 116 shows how the pattern is developed when the center of the ogee is flaring as shown from 3 to 4 in elevation. First draw the elevation A B C D, making the diameter of A B equal to 7 inches, the diameter of D C 4 inches, and the vertical height of the ogee $1\frac{3}{4}$ inches. Through the center of the elevation draw the center line *f h*, and with any point upon it as *i*, draw the half plan through A B and C D in elevation as shown respectively by E F and H G. Now divide the curved parts of the ogee into equal spaces as shown from 1 to 3 and 4 to 6. Draw a line through the flaring portion until it meets the center line *f h* at *j*. *j* will, therefore, be the center with which to strike the pattern. Take the stretchout of the curve from 3 to 1 and 4 to 6 and place it on the flaring line from 3 to 1′ and 4 to 6′ as shown by the figures. Then will 1′ 6′ be the stretchout for the ogee. It should be under-

stood that no hammering is done to that part shown from 3 to 4. The portion shown from 3 to 1′ is stretched to meet the required profile 3 2 1, while the lower part 4 to 6′ is raised to conform with the lower curve 4 5 6. Therefore, knowing that the points 3 and 4 are fixed points, then from either of these, in this case point 4,

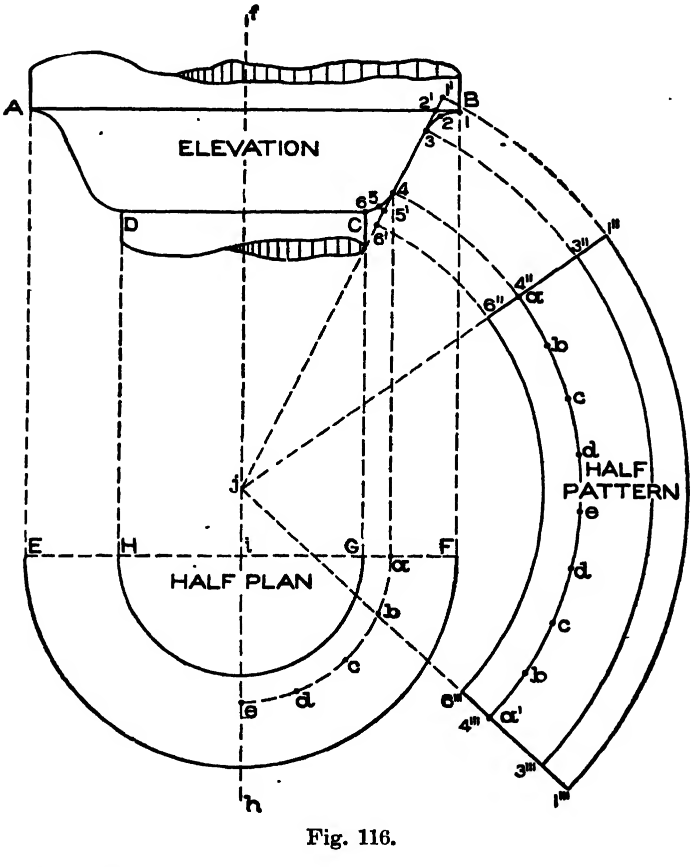


Fig. 116.

drop a vertical line intersecting the center line E F in plan at *a*. Then with *i* as center and *i a* as radius, describe the quarter circle *a e*, and space it into equal parts as shown by *a*, *b*, *c*, *d*, *e*, which represent the measuring line in plan on the point 4 in elevation. Using *j* as center, and *j* 6′, *j* 4, *j* 3 and *j* 1′ as radii, draw the arcs 1″-1‴, 3″-3‴, 4″-4‴ and 6″-6‴ as shown. From 1″ draw a radial line to *j* intersecting all the arcs as shown. Now starting at 4″ step off on

the arc $4''$-$4'''$ twice the stretchout of the quarter circle *a e* as shown by similar letters *a* to *e* to *a'* in pattern. From *j* draw a line through *a'* intersecting all of the arcs as shown. $1''$-$1'''$-$6'''$-$6''$ shows the half pattern for the ogee.

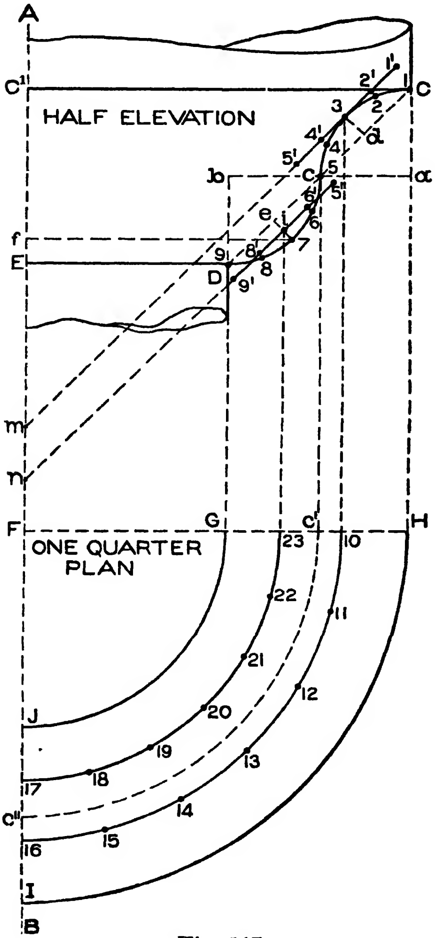


Fig. 117.

While in the previous problem the greater part of the ogee was flared, occasion may arise where the ogee is composed of two quarter circles struck from centers as shown in Fig. 117. First draw the center line A B, then draw the half diameter of the top C^1 C equal to $3\frac{1}{4}$ inches and the half diameter E D $1\frac{3}{4}$ inches. Make the vertical height of the ogee $1\frac{1}{2}$ inches, through the center of which draw the horizontal line *a b*. From C and D draw vertical lines intersecting the horizontal line *a b*, at *a* and *b* respectively. Then using *a* and *b* as centers with radii equal respectively to *a* C and *b* D draw the quarter circles shown completing the ogee. In the quarter plan below which is struck from the center F, G J and H I are sections respectively on D E and C C^1 in elevation. The methods of obtaining the patterns in this case are slightly different than those employed in the previous problems. The upper curve shown from C to *c* will have to be stretched, while the lower curve shown from *c* to D will have to be raised. Therefore in the stretchout of the pattern of the upper part from $1'$ to 3 and 3 to $5'$ the

edges must be stretched so as to obtain more material to allow the metal to increase in diameter and conform to the desired shape shown from 1 to 3 and 3 to 5. In the lower curve the opposite method must be employed. While in the upper curve the edges had to be stretched to increase the diameters, in the lower curve the edges must be drawn in by means of raising, to decrease the diameter, because the diameters to the points 5″ and 9′ are greater than to points *c* and *d*.

To obtain the pattern for the upper curve C *c* which must be stretched, draw a line from C to *c*; bisect it and obtain *d*, from which erect the perpendicular *d* 3 intersecting the curve at 3. Through 3 draw a line parallel to C *c* intersecting the center line A B at *m*. Now divide the curve C *c* into equal spaces as shown from 1 to 5 and starting from the point 3 set off on the line just drawn on either side of 3 the stretchout shown from 3 to 1′ and 3 to 5′. 1′ 5′ shows the amount of material required to form the curve C *c*. In this case 3 represents the stationary point of the blank on which the pattern will be measured. Therefore from 3 drop a vertical line intersecting the line F H at 10. Then using F as center and F 10 as radius, describe the arc 10 16, and divide it into equal spaces as shown from 10 to 16. Now with radii equal to *m* 5′, *m* 3 and *m* 1′, Fig. 117, and with *m* in Fig. 118 as center, describe the arcs 5 5′, 3 3′ and 1 1′. Draw the radial line *m* 1 intersecting the two inner arcs at 3 and 5. As the arc 3 3′ represents the stationary point 3 in elevation in Fig. 117, then set the dividers equal to the spaces 10 16 in plan and step off similar spaces in Fig. 118 on the arc 3 3′, starting at 3 as shown by similar numbers 16 to 10. Through 10 draw a line to the apex *m*, intersecting the inner curve at 5′ and the outer curve at 1′. 1 1′ 5′ 5 is the quarter pattern for the upper curve or half of the ogee, to which laps must be allowed for riveting and brazing.

For the pattern for the lower curve in elevation in Fig. 117 draw a line from *c* to D; bisect it at *e* and from *e* erect a perpendicular intersecting the curve at 7. From 7 draw a horizontal line intersecting the center line at *f*. Now the rule to be followed in "raising" is as follows: Divide the distance from *e* to 7 into as many parts, as the half diameter F 7 is equal to inches. In this case 7 *f* equals 2¼ inches; (any fraction up to the ½ inch is not

taken into consideration, but over $\frac{1}{2}$ inch one is added). Therefore for $2\frac{1}{4}$ inches use 2. Then divide the distance from *e* to 7 into two parts as shown at *i* and through *i* parallel to *c* D draw a line as shown intersecting the center line at N. Now divide the curve *c* to D into equal spaces as shown by the figures 5 to 9. Let off on either side of *i* the stretchout from 5 to 9 as shown from 5″ to

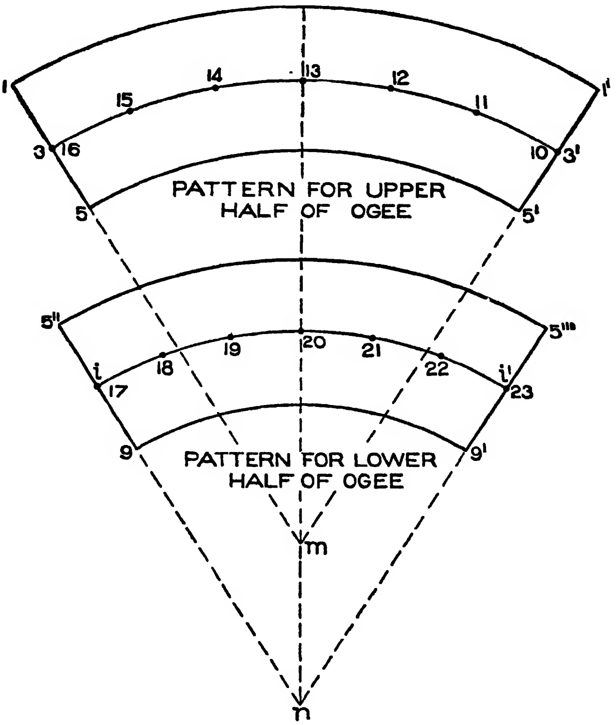


Fig. 118.

9′. From *i* drop a vertical line intersecting F II in plan at 23. Then using F as center draw the arc 23 17 as shown, which represents the measuring line in plan on *i* in the stretchout.

The student may naturally ask, why is *i* taken as the measuring line in plan, when it is not a stationary point, for when "raising" *i* will be bulged outward with the raising hammer until it meets the point 7. In bulging the metal outward, the surface at *i* stretches as much as the difference between the diameter at *i* and

7. In other words, if the measuring point were taken on 7 it would be found that after the mould was "raised" the diameter would be too great. But by using the rule of dividing *e* 7 into as many parts as there are inches in *f* 7 the diameter will be accurate while this rule is but approximate. In this case *e* 7 has only been divided into two equal parts, leaving but one point in which a line would be drawn through parallel to *c* D. Let us suppose that the semi-diameter 7 *f* is equal to eleven inches. Then the space from *e* to 7 would be divided into just so many parts, *and through the first part nearest the cove* the line would be drawn parallel to *c* D and used as we have used *i*. Now with radii equal to $n\ 9'$, $n\ i$, and $n\ 5''$ and n in Fig. 118 as center, describe the arcs $5''\ 5'''$ $i\ i'$ and $9\ 9'$. From any point as $5''$ draw a line to n intersecting all the arcs shown. Now take the stretchout from 17 to 23 in plan, Fig. 117, and starting from 17 in Fig. 118 mark off equivalent distances on the arc $i\ i'$ as shown. Draw a line through 23 to the apex n, intersecting the inner and outer arcs at $9'$ and $5'''$. Then will $9\ 5''\ 5'''\ 9'$ be the greater pattern for the lower part of the ogee.

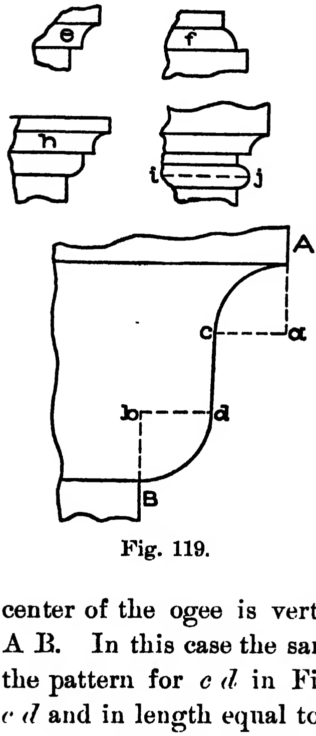


Fig. 119.

Another case may arise where the center of the ogee is vertical as shown from *c* to *d* in Fig. 119 in A B. In this case the same principles are applied as in Fig. 117; the pattern for *c d* in Fig. 119 being a straight strip as high as *c d* and in length equal to the quarter circumference $c'\ c''$ in plan in Fig. 117 which is the section on *c* in elevation. These rules are applicable to any form of mould as shown in Fig. 119, by *e*, *f*, *h*, and *j*. The bead *i* in *j* would be made in two pieces with a seam at *i* as shown by the dotted line, using the same method as explained in connection with *c* D in elevation in Fig. 117.

The coppersmith has often occasion to lay out the patterns for curved elbows. While the sheet metal worker lays them out

in pieces, the coppersmith's work must form a curve as shown in Fig. 120 which represents a curved elbow of 45°.

In Fig. 121 is shown how an elbow is laid out having 90°, similar principles being required for any degree of elbow. First draw the side elevation of the elbow as shown by A B C D, mak-

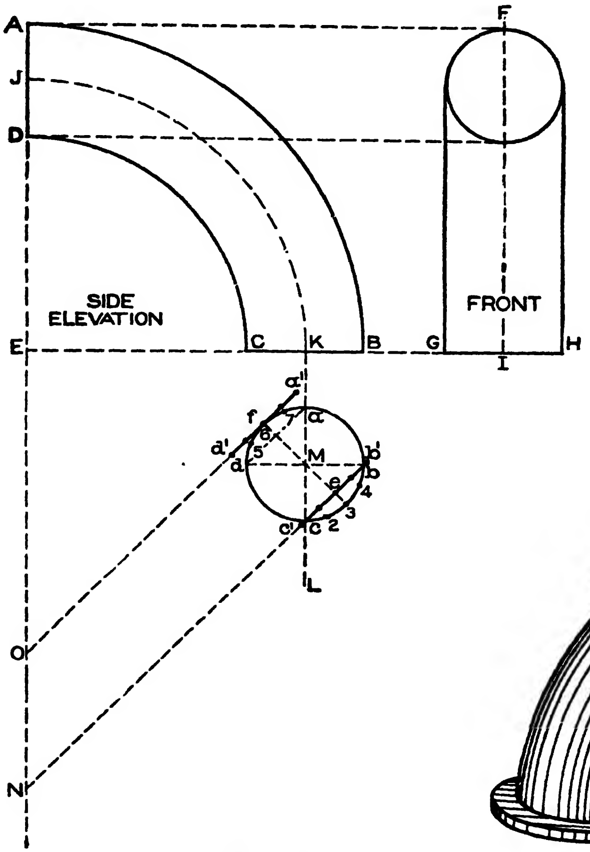


Fig. 121.

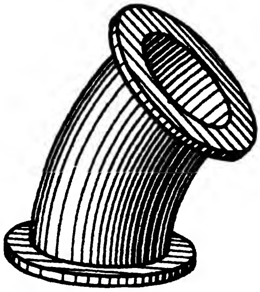


Fig. 120.

ing the radius E B equal to $4\frac{1}{2}$ inches and the diameter B C 2 inches. Bisect C B at K. Then with E as center and E K as radius draw the arc K J representing the seam at the sides. Draw the front view in its proper position as F G H, through which draw the center line F I representing the seam at back and front, thus making the elbow in four pieces. Directly below C B draw

the section of the elbow as shown by *a b c d* struck from M as center. Through M draw the diameters *b d* and *a c*. The inner curve of the elbow *a d c* in plan will be stretched, while the outer curve *a b c* in plan will be raised. Through M draw the diagonal 3 6 intersecting the circle at 3 and *f* respectively. Now draw *a d;* through *f* parallel to *a d* draw a line intersecting the center

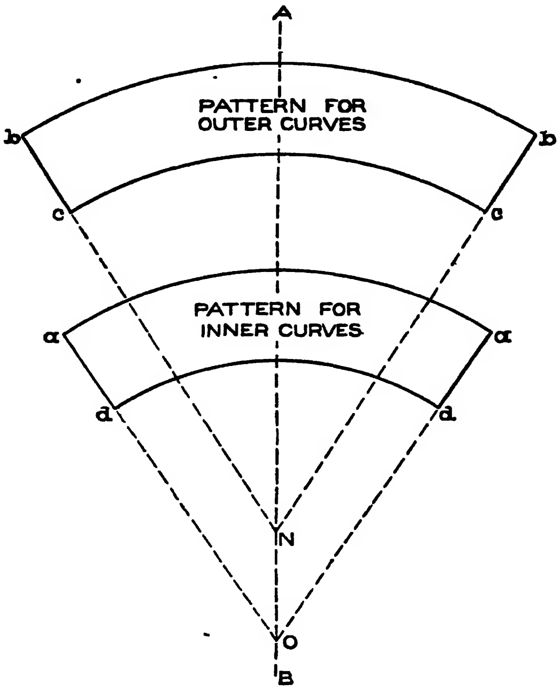
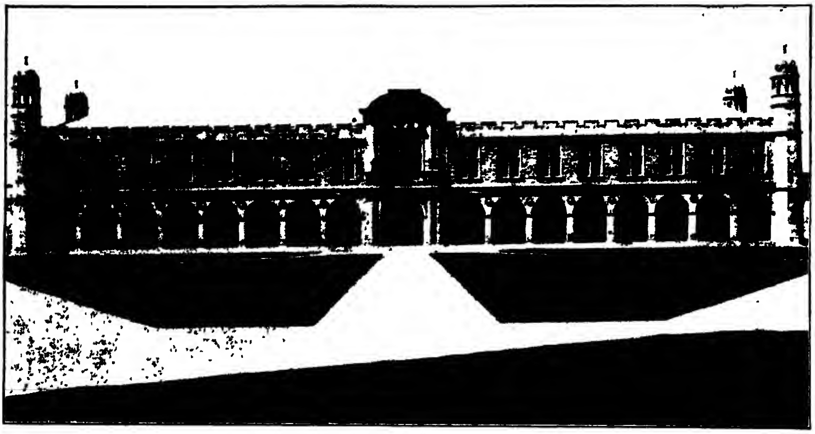


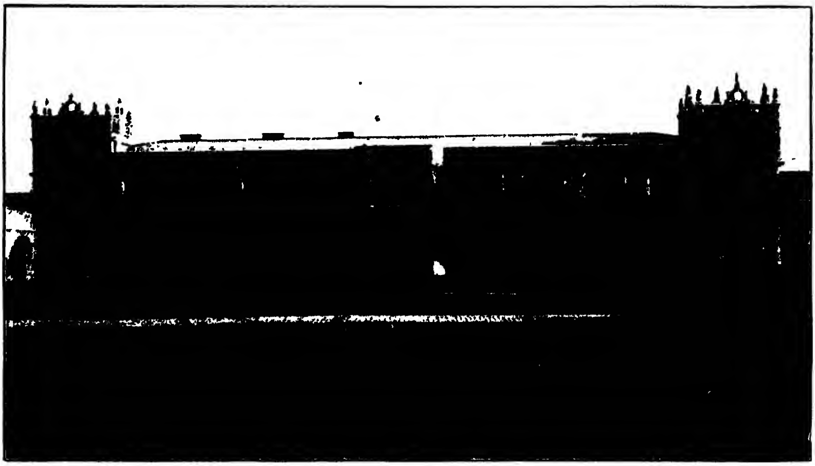
Fig. 122.

line A E extended at O. On either side of *f* place the stretchout of 6 *a* and 6 *d* as shown by *f a'* and *f d'*. Then with radii equal to O *d'* and O *a'* and with O on the line A B, Fig. 122, as center describe the arcs *d d* and *a a*. Make the length of *d d* equal to the inner curve D C in Fig. 121. From *a* and *d* in Fig. 122 draw lines to the apex O extending them to meet the outer curve at *a* and *a*. Then will *a d d a* be the half pattern for the inner portion of the elbow for two sides. The radius for the pattern for the outer curve is shown in Fig. 121 by N *c'*, N *b'*, placing the

Cupples Hall, No. 2. Building is 207 Feet Long, 47 Feet Wide. First Floor Devoted to Mechanical Engineering, Second Floor, to Electrical Engineering.



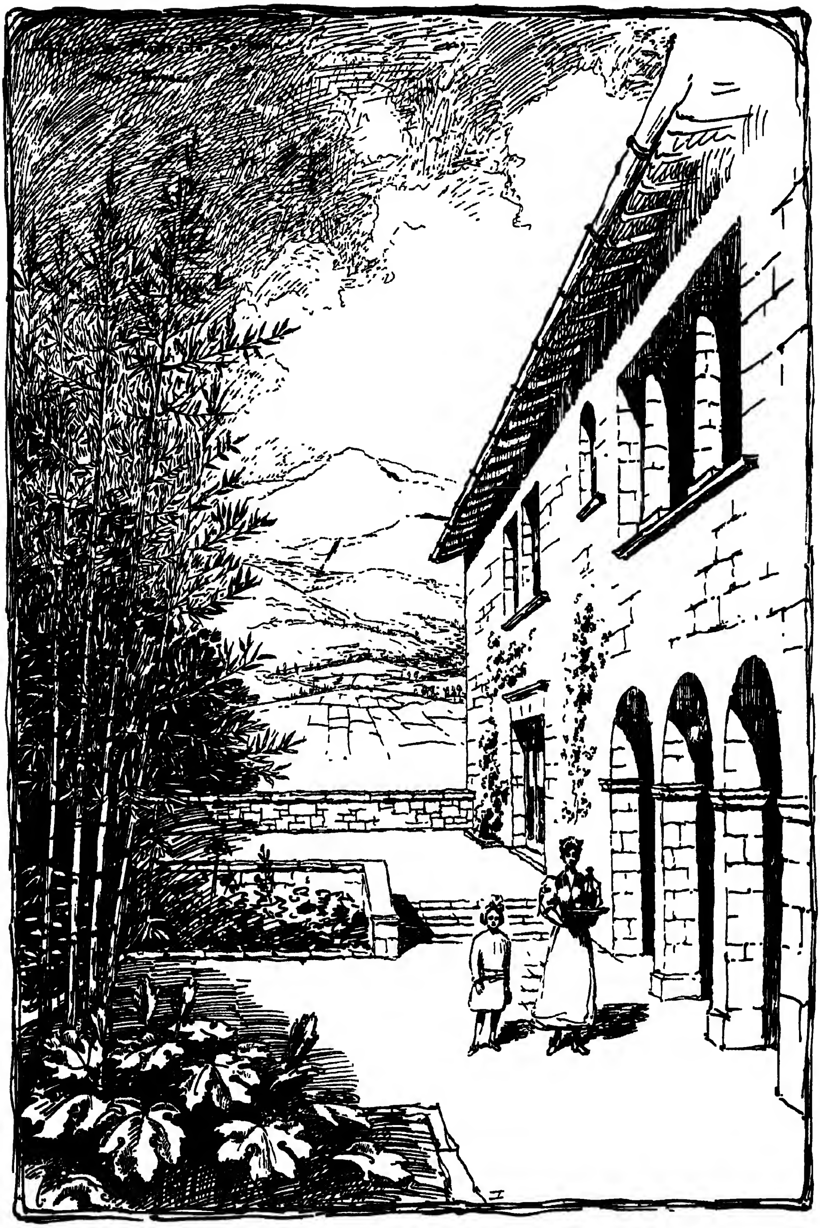
The Library. The Building is 257 Feet Long, 46 Feet Wide. The Reading Room is 100 Feet by 41 Feet. The Stacks for Books Have Room for Over 400,000 Volumes. Cost of Building, $250,000.



Busch Hall, the Chemical Laboratory. The Building is 290 Feet Long, 60 Feet Wide. Cost $110,000.

THREE FIREPROOF BUILDINGS OF THE UNIVERSITY OF WASHINGTON, ST. LOUIS, MO.

Illustrating the Restful Effect of a Long, Almost Unbroken Roof-Line.



TERRACE OF HOUSE AT MONTECITO, CALIFORNIA

Myron Hunt & Elmer Grey, Architects, Los Angeles, Cal.

For Perspective View of Building, See Page 138; Basement, First, and Second Floor Plans Shown on Page 154.

stretchout of the curve on either side of the point *e*. *b b c c* in Fig. 122 shows the pattern for the outer curve, the length *b b* being obtained from A B in elevation in Fig. 121.

In work of this kind the patterns are made a little longer, to allow for trimming after the elbow is brazed together. Laps must be allowed on all patterns for brazing.

Fig. 123 shows a perspective view of a brewing kettle, made in horizontal sections and riveted. The same principles which were employed for obtaining the patterns for a sphere in Fig. 114 are applicable to this problem. Thus in Fig. 124, let A B C represent a full section of a brewing kettle as required according to architect's design. Through the middle of the section draw the center line D E. Now divide the half section B to C into as many parts as the kettle is to have pieces as shown by *c*, *d*, *e*, *f*. From these small letters draw horizontal lines through the section, as shown by *c* A, *d d'*, *e e'*, and *f f''* and in its proper position below the section, draw the plan views on each of these horizontal lines in elevation, excepting *d' d*, as shown respectively by I F G H, *e'' e'''* and *f''' f''''*, all struck from the center *a*. Now through the points *c d* draw a line which if extended would meet the center line. Then this intersection would be the center with which to draw the arcs *c c'* and *d d''*; the flange *c b* would be added to the pattern as shown by *b'*. The stretchout for this pattern 1' would be obtained from the curved line F G H I in plan and stepped off on the outer arc *c c'*. In similar manner through *d e*, *e f*, and *f* C draw the lines intersecting the center line D E at K, L, and C. Then using the points as center, describe the patterns 2', and 3', and the full circle 4'.

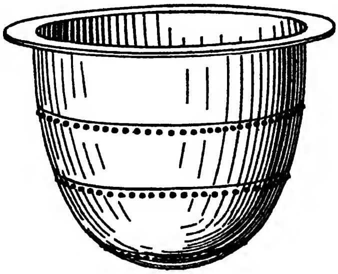


Fig. 123.

The stretchout for the patterns 2' and 3' is obtained from the circle *e'' e'''* in plan and placed on the inner curve of the pattern 2', and on the outer curve of the pattern 3'. If desired the stretchout could be taken from *f''' f''''* in plan, and placed on the inner curve of 3' which would make the pattern similar as before.

In large kettles of this kind, the length of the pattern is guided by the size of the sheets in stock, and if it was desired that each ring was to be made in 8 parts then the respective circle in plan from which the stretchout is taken would be divided into 8 parts, and one of these parts transferred to the patterns, to which laps must be allowed for seaming and riveting.

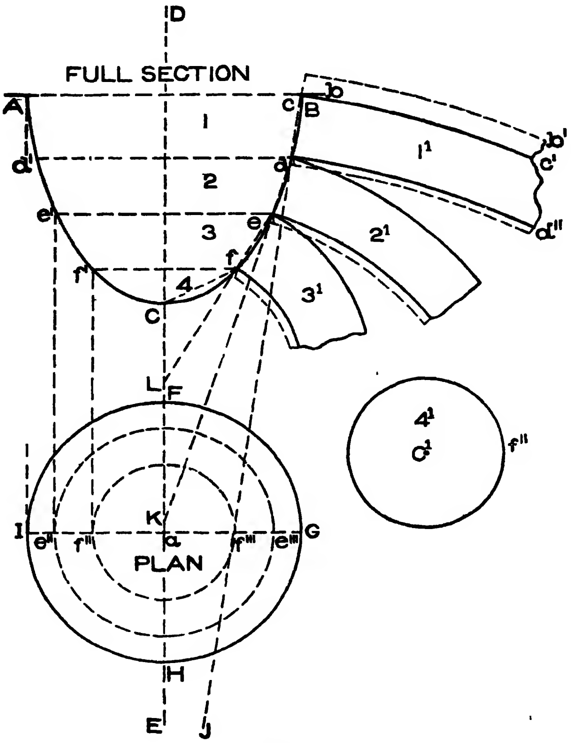


Fig. 124.

PROBLEMS FOR WORKERS IN HEAVY METAL.

While all of the problems given in this course are applicable to developments in heavy metal as well as in that of lighter gauge, the following problems relate to those forms made from boiler plate.

When using metal of heavier gauge than number 20, for pipes, elbows, or any other work, it is necessary to have the exact inside diameter. It is customary in all shops working the heavier metal,

to add a certain amount to the stretchout to make up for the loss incurred in bending, in order that the inside diameter of the article (pipe, stack, or boiler shell) may be kept to a uniform and desired size. This amount varies according to different practice of workmen, some of whom allow 7 times the thickness of the metal used, while others add but 3 times the thickness. Theoretically the amount is 3.1416 times the thickness of the metal.

For example, suppose a boiler shell or stack is to be made 48 inches in diameter out of $\frac{1}{2}$-inch thick metal. If this shell is to measure 48 inches on the inside, add the thickness of the metal, which is $\frac{1}{2}$ inch, making $48\frac{1}{2}$ inches. Multiply this by 3.1416 and the result will be the width of the sheet. If, on the other hand, the outside diameter is to measure 48 inches, subtract the thickness of the metal, which would give $47\frac{1}{2}$ inches and multiply that by 3.1416 which would give the proper width of the sheet. It is well to remember that no matter what the thickness of the plate may be, if it is not added, the diameter of the finished article will not be large enough; for where no account is taken of the thickness of the metal, the diameter will measure from the center of the thickness of the sheet. While this rule is theoretically correct there is always a certain amount of material lost during the forming operations. It is, therefore, considered the best practice to use seven times the thickness of the metal in question. The circumference for a stack 48 inches in diameter inside using $\frac{1}{2}$ inch metal would be, on this principle, $3.1416 \times 48 + (7 \times \frac{1}{2})$ to which laps would have to be allowed for riveting. Where the stack has both diameters equal a butt joint is usually employed with a collar as shown at either *a* or *b* in Fig. 125, but where one end of the stack is to fit into the other, a tapering pattern must be obtained which will be described as we proceed.

In putting up large boiler stacks it is usual to finish at the top with a moulded cap, and while the method of obtaining the patterns is similar to parallel line developments, the method of developing such a pattern will be given showing how the holes are punched for a butt joint.

In Fig. 126 a view of the moulded cap on a stack is shown. On a large size stack the cap is often divided into as many as 32 pieces. If the stack is to be made in horizontal sections the rules

given in the problems on coppersmithing apply. While in obtaining the patterns for a cap in vertical sections, the plan is usually divided into 16 to 32 sides, according to the size of the stack; we have shown in Fig. 127 a quarter plan so spaced as to give 8 sides to the full circle. This has been done to make each step distinct, the same principles being applied no matter how many sides the plan has.

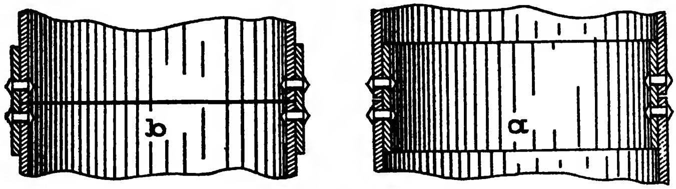


Fig. 125.

First draw the center line A B and with any point as C with radius equal to $4\frac{1}{2}$ inches draw the quadrant D E. Now tangent to D and E, draw the line D F and E G, and at an angle of 45°, tangent to the curve at Y, draw G F intersecting the previous lines drawn at G and F. C D F G E shows the plan view of the extreme outline of the cap. Directly above the plan draw a half section of the cap, the curve 5 8 being struck from *b* as center and with a radius equal to *b* 8 or $1\frac{3}{4}$ inches. Then using the same radius with *a* as center describe the quarter circle 5 2. Make 2 1 equal to $\frac{5}{8}$ inch, and 8 9 one inch. From the corners F and G in plan draw the miter lines F C, C G. Divide the profile of the cap into equal spaces as shown by the figures 1 to 9, from which drop vertical lines, intersecting the miter line F C as shown. On C D extended as C H place the stretchout of the profile of the cap as shown by similar numbers. At right angles to D H draw lines as shown, and intersect them by lines drawn parallel to D H from the intersections on C F. Trace a line through points thus obtained as shown by J I and trace this outline on the opposite side of the

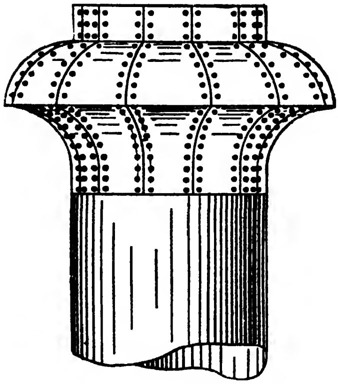


Fig. 126.

line D H as shown by J^1 I^1. Then will J I I^1 J^1 be the complete pattern for one side.

When riveting these pieces together an angle is usually placed on the inside and the miters butt sharp, filing the corners to make a neat fit. This being the case the holes are punched in the pattern before bending as shown by X X X etc. Assuming that the

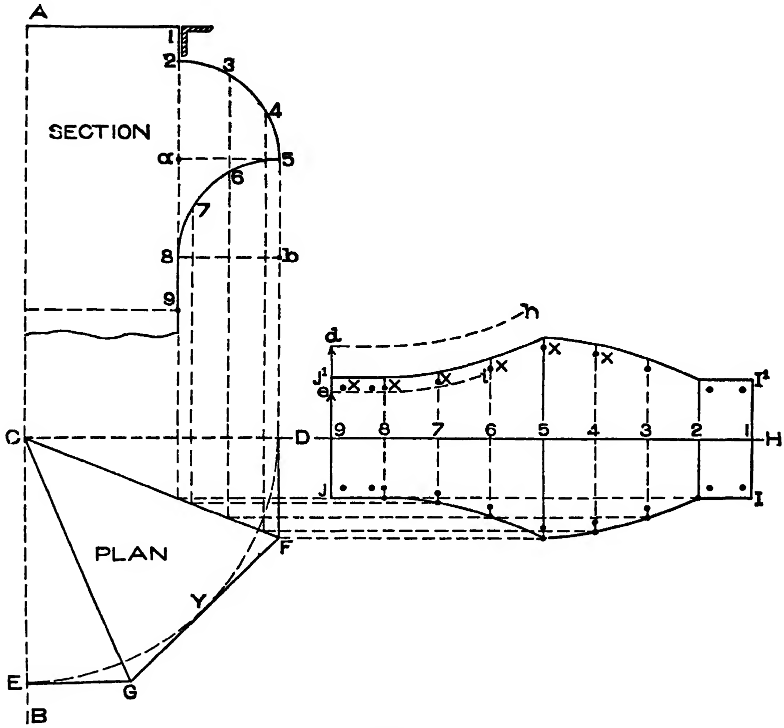


Fig. 127.

stack on which the cap is to fit is 48 inches in diameter, obtain the circumference as previously explained and divide by 8 (because the plan is composed of 8 pieces) placing one-half of the distance on either side of the center line D H in pattern. Assuming that $\frac{1}{16}$ of the circumference is equal to 9 *e*, trace from *e* the entire miter cut, as partly shown by *e i* to the line I^1 I. If the $\frac{1}{16}$ circumference were equal to 9 *d*, the cut would then be traced as shown in part by *d h* until it met the line I I^1. This, of course,

would be done on the half pattern 9 J I I before tracing it opposite the center line D H. Should the plan be divided into 32 parts, divide the circumference of the stack by 32 and place $\frac{1}{64}$ of the circumference on 9 J in pattern, measuring from the center line D H, and after obtaining the proper cut, trace opposite the line D H.

In constructing a stack where each joint tapers and fits inside of the other, as shown in Fig. 128, a short rule is employed for obtaining the taper joints without having recourse to the center. In the illustration *a b* represents the first joint, the second C slip-

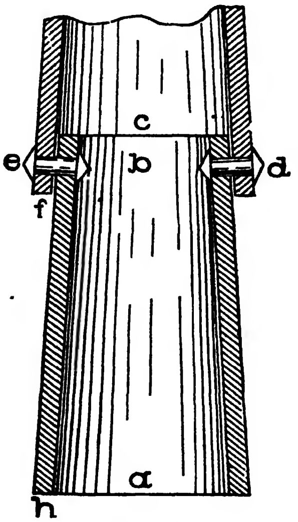


Fig. 128.

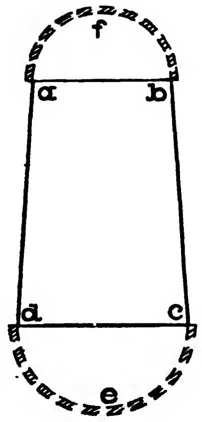


Fig. 129.

ping over it with a lap equal to *f*, the joint being riveted together at *e* and *d*. When drawing the first taper joint *a b*, care must be taken to have the diameter at *f* on the outside, equal to the inside diameter at the bottom at *h*. This allows the second joint to slip over a certain distance so that when the holes are punched in the sheets before rolling, the holes will fit over one another after the pipe is rolled.

In Fig 129 *a b c d* is a taper joint drawn on the line of its inside diameter, as explained in Fig. 128 *f*, and *e* in Fig 129 represents respectively the half sections on *a b* and *d c*. By the short rule the radial lines of the cone are produced without having

recourse to the apex, which, if obtained in the full-size drawings, would be so far away as to render its use impracticable. A method similar to the following is used for obtaining the arcs for the pattern in all cases where the taper is so slight as to render the use of a common apex impracticable.

Let *a b c d*, Fig. 130, be a reproduction of *a b c d* in Fig. 129. On either side of *a d* and *b c*, in Fig. 130, place duplicates of *a b c d* as shown by *b′ c′* and *a′ d′*. This can be done most accurately by using the diagonals *d b* and *c a* as radii, and with *d* and *c* as centers describe the arcs *b b′* and *a a′* respectively, and intersect

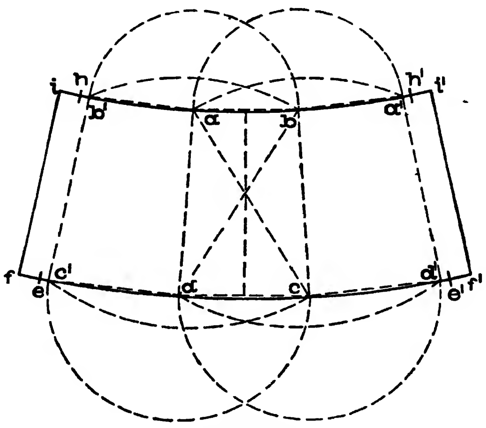


Fig. 130,

them by arcs struck from *a* and *b* as centers, with radii equal respectively to *a b* and *b a* as shown. In precisely the same manner obtain the intersection *c′* and *d′* at the bottom. Now through the intersections *b′ a b a′* and *d′ c d c′* draw the curve as shown by bending the straight-edge or any straight strip of wood placed on edge and brought against the various intersections, extending the curves at the ends and top and bottom indefinitely. Since the circumference of the circle is more than three times the diameter, and as we only have three times the diameter as shown from *c′* to *d′* and *b′* to *a′*, then multiply .1416 times the bottom and top diameter *d c* and *a b* respectively, and place one-half of the amount on either side of the bottom and top curves as shown by *e*, *e′*, and *h*, *h′*. Now take one-half of seven times the thickness of the metal in use and place

it on either side on the bottom and top curves as shown by *f*, *f'* and *i*, *i'*, and draw a line from *i* to *f* and *i'* to *f'*. To this lap must be allowed for riveting. The desired pattern is shown by *i i' f' f*.

Fig. 131 shows a three-pieced elbow made from heavy metal, the two end pieces fitting into the center pieces, to which laps are allowed for riveting. The principles which shall be explained to cut these patterns and make the necessary allowance for any thickness of metal is applicable to any elbow.

In Fig. 132 draw as previously described the elbow A B C, below G H draw the section of the inside diameter as D which is struck from *a*, and divide into equal spaces as shown by the figures 1 to 5 on both sides. Through these figures draw vertical lines intersecting the miter line *b c*, and from these intersections parallel to *c d* draw lines intersecting the line *d e* as shown.

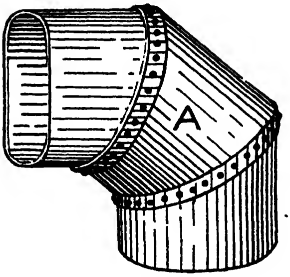


Fig. 131.

Before obtaining the stretchout for these elbows, a preliminary drawing must be constructed, in which an allowance is made for the thickness of the material that is to be used. This drawing makes practical use of a principle well known to draughtsmen from its application to the proportional division of lines and is clearly shown at (R). In allowing for the thickness of the metal in use, it is evident that we cannot allow it at one end, but must distribute it uniformly throughout the pattern. In (R) draw any horizontal line as E F, upon which place the stretchout of the inside diameter of the pipe D, as shown by similar figures on E F. From 1^o on E F lay off the distance 1^o *m* equal to 7 times the thickness of the metal in use as before explained. Then using E as center and E *m* as radius, draw the arc *m* 1' intersecting the vertical line drawn from 1^o, and from the various intersections from 1 to 1^o on E F erect perpendiculars intersecting the slant line 1 1' at 2' 3' 4', etc., as shown. The slant line 1 1 with the various intersections is now the correct stretchout for the elbow made of such heavy material called for by the specifications. On G H extended, as H I, place the stretchout of the slant line 1 1' as shown from 1 to 1' on H I. At right angles to H I and

from the various intersections, erect lines, which are intersected by lines drawn parallel to H I from similar numbered intersections on the miter line *b c*. Trace the curve L M. L M I H shows the pattern for the two end pieces of the elbow.

As the middle section A in Fig. 131 is to overlap the two end pieces, it is unnecessary to allow for any additional thickness on

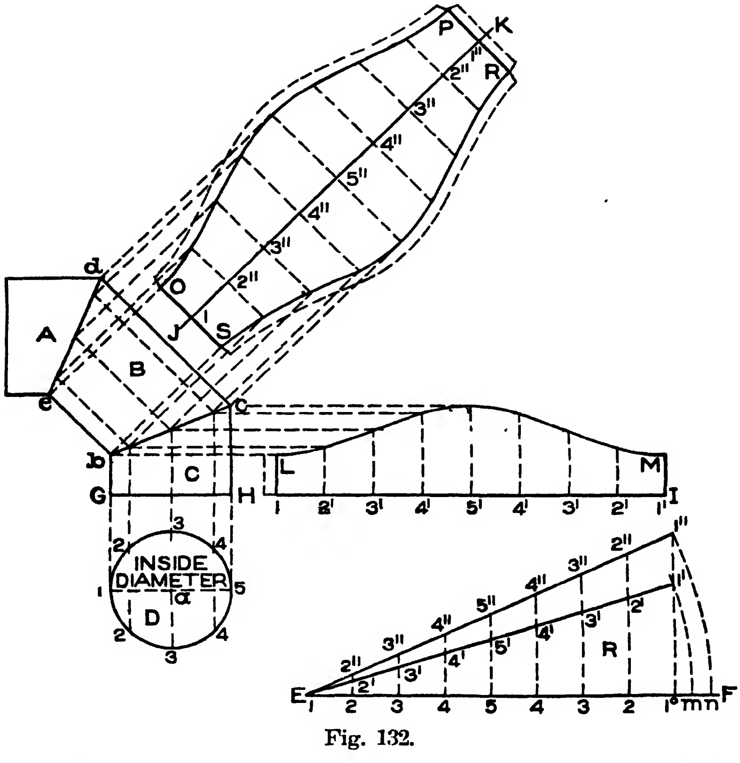


Fig. 132.

account of this lap when suitable flanging machines are available; but since it is desirable, in some instances, to make an allowance in the pattern for riveting, the method of allowing for this lap will be explained.

In (R), Fig. 132, lay off on the line E F the distance *m n* equal to 7 times the thickness of the metal in use, and with radius equal to E *n* draw an arc intersecting the line 1° 1′ extended at 1″. Draw the slant line from 1″ to 1 and extend all the vertical lines to intersect 1 1″ at 2″ 3″ 4″, etc. The slant line 1 1″ is the cor-

rect stretchout for the middle section B. At right angles to *d c* draw J K equal to 1 5″ 1″ in (R), as shown by similar figures in J K, through which draw lines at right angles to J K, and intersect them by lines drawn at right angles to *d c* as shown. Trace the curved lines to produce O P R S, which is the pattern for the middle section, to which flanges are allowed as shown by dotted lines.

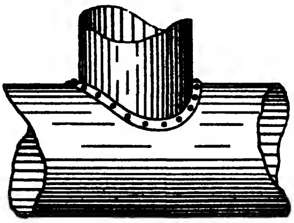


Fig. 133.

The perspective of an intersection between pipes having different diameters in boiler work is shown in Fig. 133. While the method of obtaining the patterns is similar in principle to parallel line developments, a slight change is required in obtaining the allowance in the stretchout for the thickness of the metal in use.

Let A B, Fig. 134, represent the part section of a boiler struck with a radius equal to $3\frac{3}{8}''$ and let 1 7 7° 1° be the elevation of the intersecting pipe, whose inside diameter is $4\frac{7}{8}''$, as shown by 1 7.

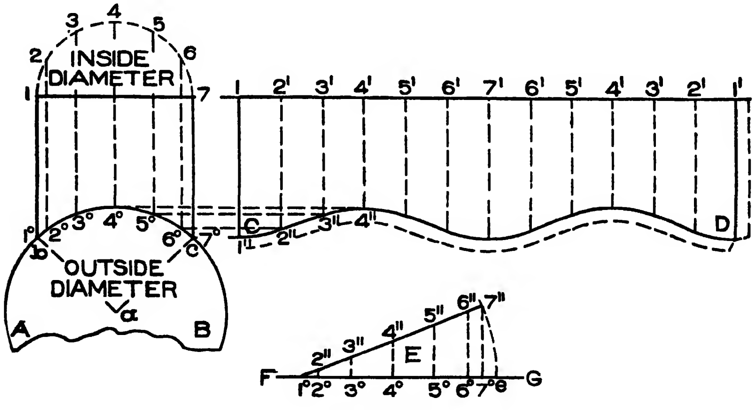


Fig. 134.

Divide the half section 1 4 7 into an equal number of spaces, as numbered, from which drop vertical lines intersecting the outside line of the boiler at 1° to 7° as shown. A true stretchout must now be obtained in which allowance has been made for the thickness of the metal in use. Therefore, in Fig. 135, on the horizontal line A B lay off the stretchout of twice the inside section of

the pipe in Fig. 134, as shown by similar figures on A B in Fig. 135, adding 1^x *a*, equal to 7 times the thickness of the metal in use. For example, supposing $\frac{1}{4}$-inch steel was used; the distance 1^x *a* would then be equal to 7 × $\frac{1}{4}$, or $1\frac{3}{4}$ inches. Now draw the arc *a* 1′, using 1 as center, which is intersected by the vertical line drawn from 1^x. From 1′ draw a line to 1, and from the various points on A B erect perpendiculars intersecting 1 1′ at 2′ 3′ 4′, etc. 1 1′ shows the true stretchout to be be laid off on the line 1 7 extended in Fig. 134 as 1 1′, and from the various intersections on 1 1′ drop vertical lines and intersect them by lines drawn parallel to 1 1′ from similar intersections on the curve 1° 7° as shown. Trace a curved line as shown from C to D. 1 C D 1′ shows the pattern for the vertical pipe to which a flange must be allowed for riveting as shown by the dotted line.

It is now necessary to obtain the pattern for the shape to be cut out of the boiler sheet, to admit the mitering of the vertical pipe. In some shops the pattern is not developed, only the vertical pipe is flanged, as shown in Fig. 133, then set in its proper position on the boiler and line marked along the inside diameter of the pipe, the pipe is then removed and the opening cut into the boiler with a chisel. We give, however, the geometrical rule for obtaining the pattern, and either method can be used.

As A B in Fig. 134 represents the outside diameter of the boiler, to which 7 times the thickness of the metal used must be added to the circumference in laying out the sheet, and as the vertical pipe intersects one-quarter of the section as shown by *a b c*, take the stretchout from 1° to 7° and place it from 1° to 7° on F G in (E), to which add 7° *c*, equal to $\frac{1}{4}$ of 7 times the thickness of the plate used. Draw the arc *e* 7″, using 1° as center, intersecting it by the vertical line drawn from 7°. Erect the usual vertical lines and draw 7″ 1°, which is the desired stretchout. Now place this stretchout on the line A B in Fig. 136, erecting vertical lines as shown. Measuring in each and every instance from the line 1 7 in Fig. 134, take the various distances to points 2, 3, 4, 5, and 6 and place them in Fig. 136 on lines having similar numbers, measuring in each instance from A B on either side, thus obtaining the points 2, 3, 4, 5, and 6. Trace the curve 1° 4 7″ 4, which is the desired shape.

Fig. 137 shows a perspective of a gusset sheet A on a locomotive, the method of obtaining this pattern in heavy metal is shown in Fig. 138. First draw the end view A B C, the semicircle 4 1 4 being struck from *a* as center with a radius equal to 2

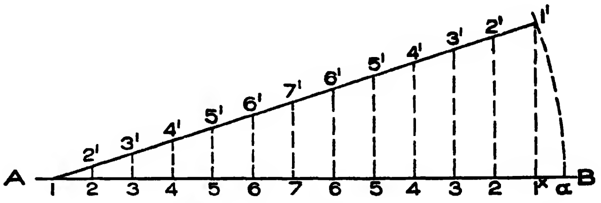


Fig. 135.

inches. Make the distance 4 to C and 4 to B both $3\frac{3}{4}$ inches and draw C B. Draw the center line A F, on which line measure up $2\frac{1}{4}$ inches and obtain *b*, which use as center with radius equal to *a* 4, draw the section of the boiler D E F G. In its proper position draw the side view H I J K L M N. H I L M N H shows the side view of the gusset sheet shown in end view by G A E D G.

Divide the semicircle 4 1 4 in end view into equal spaces as shown, from which draw horizontal lines intersecting H N in side

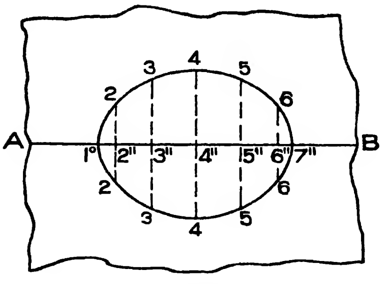


Fig. 136.

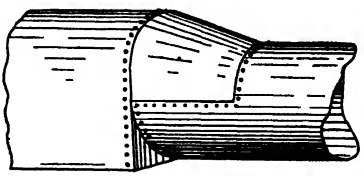


Fig. 137.

view from 1′ to 4′. From these intersections parallel to H I, draw lines indefinitely intersecting I L from 1″ to 4″. At right angles to N L produced draw the line at *c d*, on which a true section must be obtained at right angles to the line of the gusset sheet. Measuring from the line A D in end view, take the various distances to points 2, 3, and 4 and place them on corresponding lines measuring from the line *c d* on either side, thus obtaining

the intersections 1° to 4°, a line traced through these points will be the true section. In (Y) on any line as O P lay off the stretchout of the true section as shown from 4°, 1°, 4°. As the gusset sheet only covers a portion equal to a half circle, add the distance 4° *e* equal to ½ of 7 times the thickness of the metal in use and

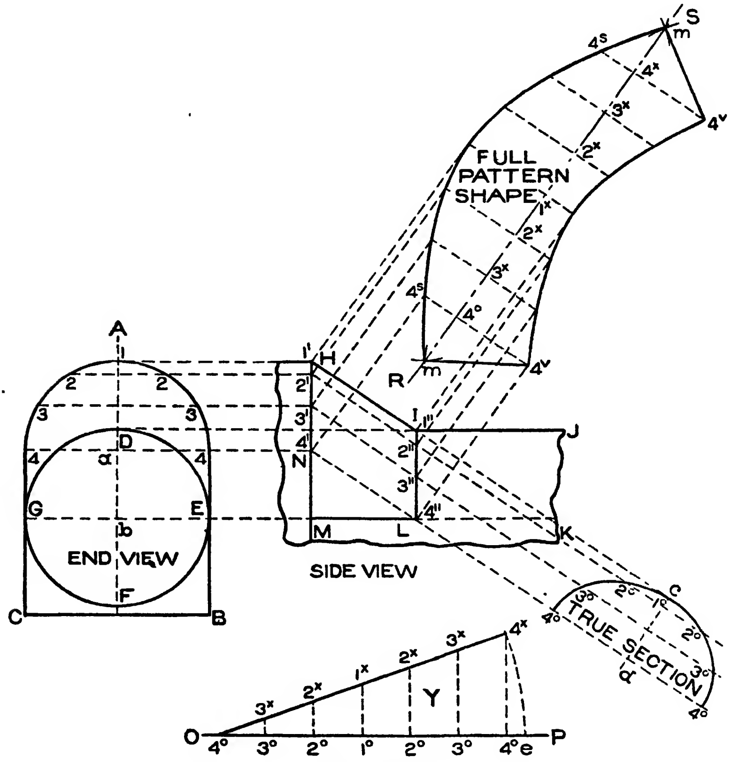


Fig. 138.

using 4° at the left, as center with 4° *e* as radius, describe the arc *e* 4^x, intersecting it at 4^x by the vertical line drawn from 4°. From O P erect vertical lines intersecting the line drawn from 4^x to 4° at 3^x, 2^x, 1^x, etc. 4° 4^x is the true stretchout, and should be placed on the line R S drawn at right angles to H I. Through the numbers on R S and at right angles draw the lines shown and intersect them by lines drawn from similarly numbered intersections on H N and I L at right angles to H I. Through points

thus obtained trace a curved line 4^S, 4^S, and 4^V, 4^V. It now becomes necessary to add the triangular piece shown by L M N in side view, to the pattern which can be done as follows: Using L M in side view as radius and 4^V at either end of the pattern as centers, describe the arcs *m* and *n*; intersect them by arcs struck from 4^S and 4^S as centers, and M N in side view as radius. Then draw lines from 4^S to *m* to 4^V in the pattern on either side. The full pattern shape for the gusset sheet will then be shown by *m* 4^S 4^S *m* 4^V 4^V, to which laps must be allowed for riveting.

Fig. 139 shows a conical piece connecting two boilers with the flare of A such that the radial lines can be used in developing the pattern. In all such cases this method should be used in preference to that given in connection with Fig. 130. Thus in Fig. 139 the centers of the two boilers are on one line as shown by *a b*. While the pattern is developed the same as in flaring work, the method of allowing for the metal used is shown in Fig. 140.

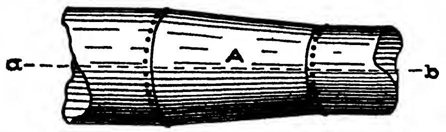


Fig. 139.

A B C D is the elevation of the conical piece, the half inside section being shown by 1 4 7 which is divided into equal spaces. 1 7 1 in (E) is the full stretchout of the inside section A 4 D in elevation, and 1 *e* is equal to 7 times the thickness of the metal used. The line 1 1′ is then obtained in the usual manner as are the various intersections 2′ 3′ 4′, etc. Now extend the lines A B and D C in elevation until they meet the center line *a b* at *a*. Then using *a c* and *a d* draw the arcs 1′ 7′ and 1″ 7″. From 1′ draw a radial line to *a*, intersecting the inner arc at 1″. Now set the dividers equal to the spaces on 1 1′ in (E) and starting from 1′ in the pattern step off 6 spaces and draw a line from 7′ to *a* intersecting the inner arc at 7″. 1′ 7′ 1″ 7″ shows the half pattern to which flanges must be allowed for riveting.

Fig. 141 shows a view of a scroll sign, generally made of heavy steel, heavy copper, or heavy brass. So far as the sign is concerned it is simply a matter of designing, but what shall be given attention here is the manner of obtaining the pattern and elevation of the scroll. As these scrolls are usually rolled up in

form of a spiral, the method of drawing the spiral will first be shown.

Establish a center point as a' in Fig. 142, and with the desired radius describe the circle shown, which divide into a polygon of

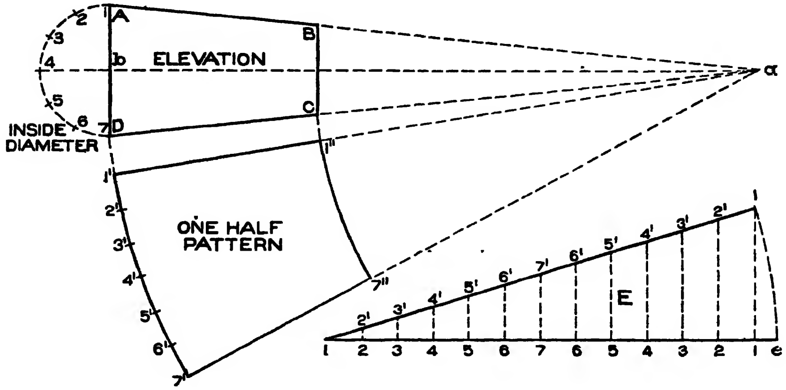


Fig. 140.

any number of sides, in this case being 6 sides or a hexagon. The more sides the polygon has, the nearer to a true spiral will the figure be. Therefore number the corners of the hexagon 1 to

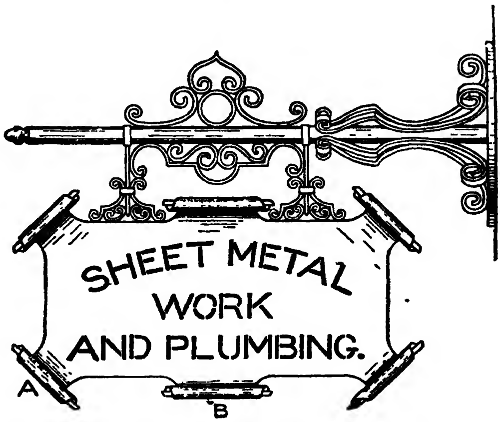


Fig. 141.

5 and draw out each side indefinitely as 1 a, 2 b, 3 c, 4 d, 5 e, and 6 f. Now using 2 as center and 2 1 as radius, describe the arc 1 A; then using 3 as center and 3 A as radius, describe the arc

A B, and proceed in similar manner using as radii 4 B, 5 C, 6 D, and 1 E, until the part of the spiral shown has been drawn. Then using the same centers as before continue until the desired spiral is obtained, the following curves running parallel to those first drawn. The size of the polygon a', determines the size of the spiral.

In Fig. 143 let A B C D represent the elevation of one corner of the flag sign shown in Fig. 141. In its proper position in Fig. 143 draw a section of the scroll through its center line in elevation as shown by a 17 to 1, which divide into equal spaces as shown from 1 to 17. Supposing the scroll is to be made of $\frac{1}{8}$ inch thick

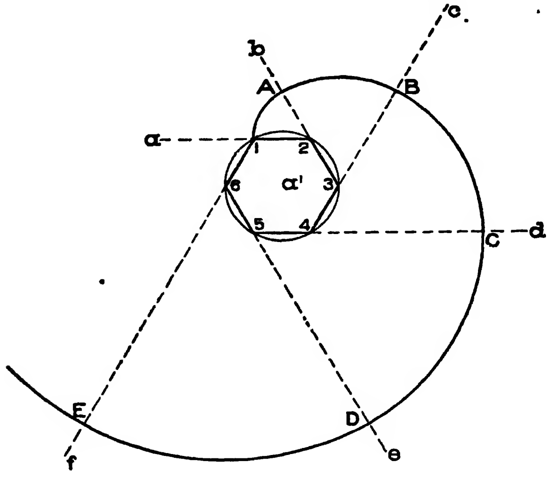


Fig. 142.

metal, and as the spiral makes two revolutions then multiply $\frac{1}{8}$ by 14, which would equal $1\frac{3}{4}$ inches. Then on E F in Fig 144 place the stretchout of the spiral in Fig. 143, as shown by similar numbers, to which add 17 E equal to 14 times the thickness of metal in use, and draw the arc E 17′ in the usual manner and obtain the true stretchout with the various intersections as shown. Through the elevation of the corner scroll in Fig. 143 draw the center line E F, upon which place the stretchout of 17′ E, Fig. 144, as shown by similar numbers on E F in Fig. 143. At right angles to E F, through 1′ and 17′, draw 17° 17° equal to A B and 1° 1° equal to the desired width of the scroll at that point. Then at pleasure draw the curve 1° 17° on either side, using the straight-

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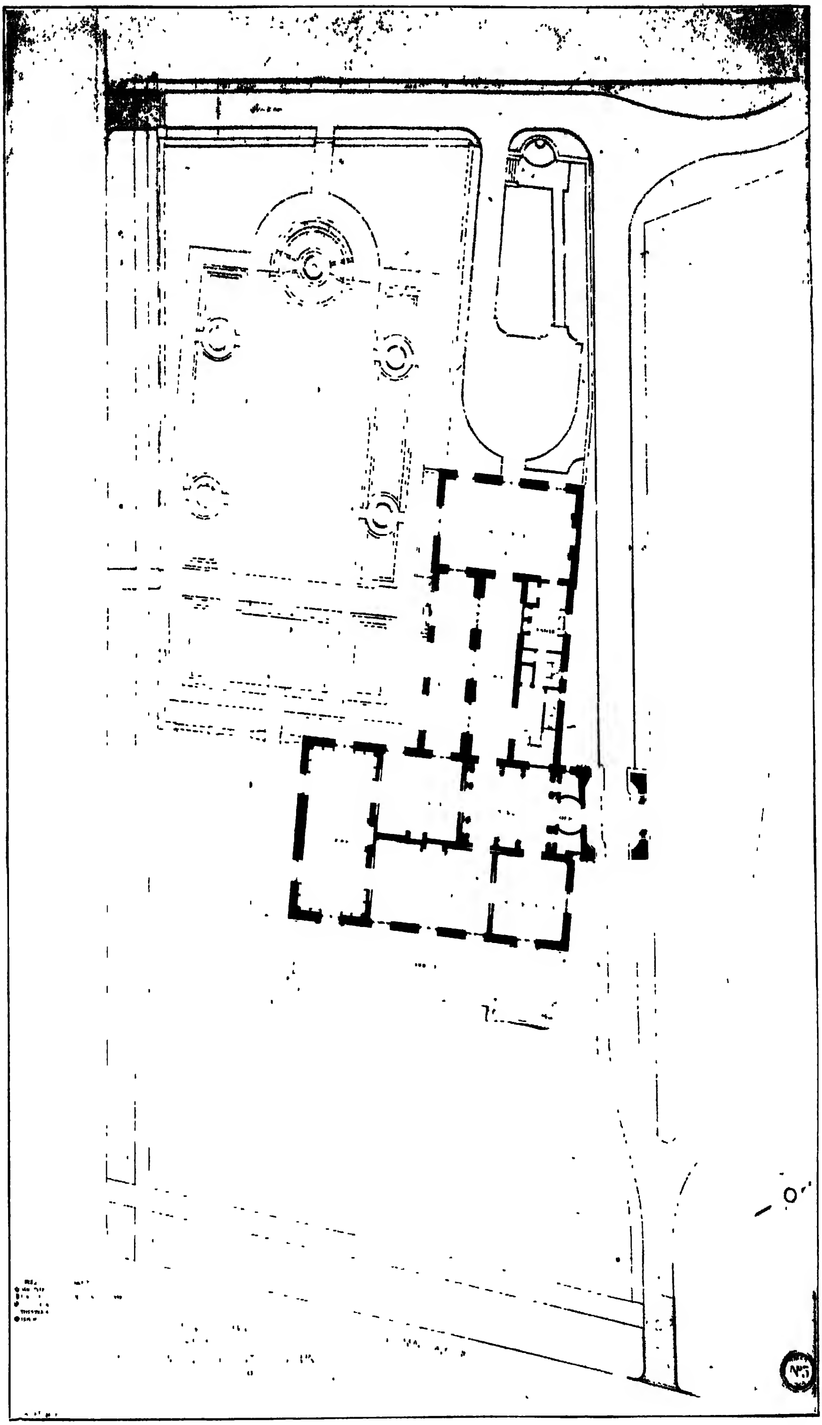
For Plan Showing Layout of Grounds, See Opposite Page.



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Carrère & Hastings, Architects, New York.

Plan Showing Layout of Grounds. For Exterior View, See Opposite Page.

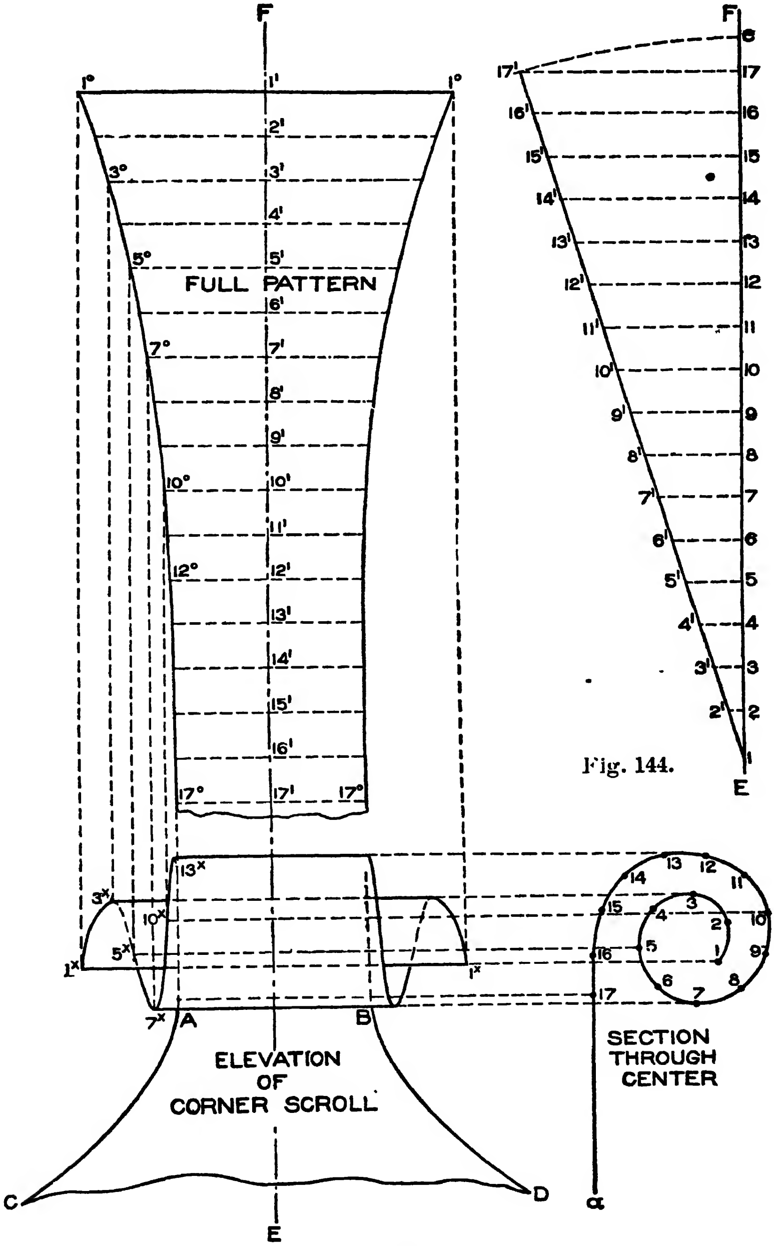


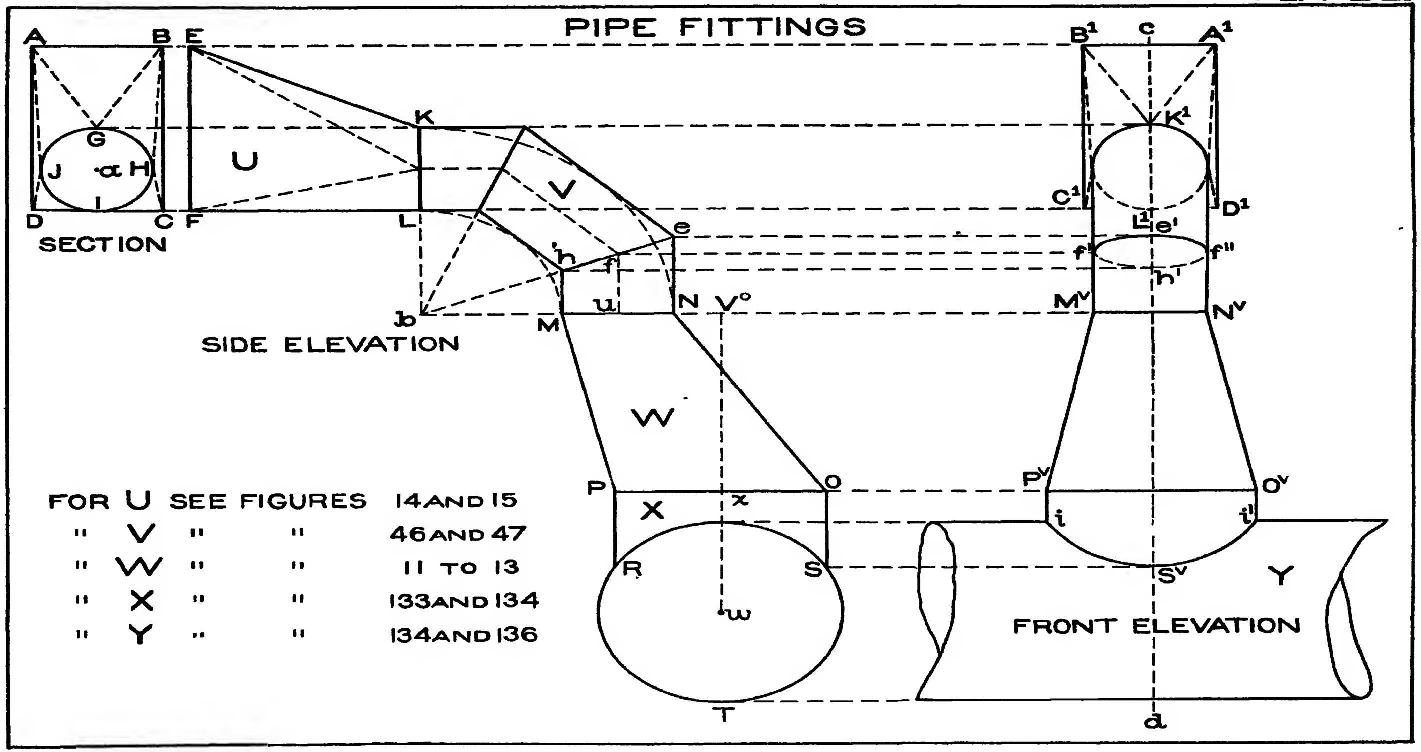
Fig. 144.

Fig. 143.

edge and bending it as required. Then will 1° 1° 17° 17° be the pattern for the scroll using heavy metal.

If it is desired to know how this scroll will look when rolled up, then at right angles to E F and through the intersections $1'$ to $17'$ draw lines intersecting the curves of the pattern 1°-17° on both sides. From these intersections, shown on one side only, drop lines intersecting similar numbered lines, drawn from the intersections in the profile of the scroll in section parallel to A B. To avoid a confusion of lines the points 1^x, 3^x, 5^x, 7^x, 10^x, 12^x, and 17^x have only been intersected. A line traced through points thus obtained as shown from 1^x to 17^x in elevation gives the projections at the ends of the scroll when rolled up.

PLATE III


PIPE FITTINGS
SECTION
SIDE ELEVATION
FRONT ELEVATION
U
V
W
X
Y
FOR U SEE FIGURES 14 AND 15
" V " " 46 AND 47
" W " " 11 TO 13
" X " " 133 AND 134
" Y " " 134 AND 136

EXAMINATION PLATES.

PLATE III.

In this plate a set of pipe fittings is shown which should be drawn by the student carefully according to the measurements which will be given. If necessary, copy it before sending for examination and correction. This plate should be laid out the same size as previous plates and the border lines drawn as before. There are five fittings shown which will require six patterns. Reproduced plates of the patterns are not sent to the student; he should work out the problems for himself according to directions given. First draw in Plate III the rectangular section A B C D, making it $1\frac{3}{8} \times 2\frac{3}{8}$ inches, with the line A B $\frac{1}{2}$-inch below the margin line, and A B $\frac{1}{4}$-inch to the right of the margin line. Now with *a* in the section as center and with radius equal to $\frac{5}{8}$-inch draw the circle G H I J so that I will be tangent at D C and G I be central in the section. Then A B C D will be the true section on E F, while G H I J shows the section on the line K L. Draw E F one-quarter inch from the line B C, and at right angles to E F, draw F L equal to $2\frac{1}{2}$ inches and from L erect the line L K $1\frac{1}{4}$ inches or equal to the height of the circle I G in section. Draw the line K E. E F L K represents the side elevation of a transition piece whose base is rectangular and whose top is round, as shown in the section. The dotted lines in section and elevations show how the figure is divided into sections of scalene cones, necessary when developing the patterns. Now extend the line K L as K *b* and with radius equal to $1\frac{1}{2}$ inches draw the quadrant L M from *b* as center. Then using *b* again as center with *b* K as radius draw the outer arc K N, intersecting the horizontal line drawn from *b*. Draw the 3-piece elbow, whose section is shown by G H I J, as explained in connection with Fig. 42, Part I. Draw the center dotted line through the elbow and from *u* on the horizonal line *b* N extended lay off a distance equal to one inch as V°. From V° measure down on a vertical line a distance equal to $4\frac{3}{8}$ inches, to the point *w*. Using *w* as center with a radius equal to $1\frac{1}{4}$ inches describe the circle R S T. From *w* on the vertical line measure

up a distance of $1\frac{3}{4}$ inches to x and through x draw the horizontal line O P, making x O and x P each $1\frac{1}{8}$ inches. From O and P drop vertical lines intersecting the circle at S and R. Draw M P and N O, forming the transition piece W, which connects round pipes with diameters equal to M N and P O respectively. X shows the side elevation of the collar connecting the main pipe R S T with the transition piece W.

A front elevation of the fittings should be drawn as follows: Draw the center dotted vertical line $c\,d$ $2\frac{5}{8}$ inches to the left of the margin line, and from the various intersections in the side elevation draw the dotted lines shown. Draw a broken view of the main pipe Y, $\frac{1}{4}$ inch from the margin line, and making both sides equal distance from the center line. Draw the intersection between the collar and main pipe as shown by i S^V i', drawing a curved line through these points. P^V O^V and M^V N^V represent the same diameters as P O and M N in side elevation. They are measured on either side of the center line $c\,d$ in front elevation. $e'\,f'\,h'\,f''$ is a front elevation through $e\,f\,h$ in side view, while L^1 K^1 is a true section on K L. A^1 B^1 C^1 D^1 is equal to A B C D in section. Draw dotted lines showing the transition from the rectangular section to round as given in the front elevation. When this has been done Plate III is completed.

We have now five fittings for which the patterns must be developed, and for which no reproduced plates are sent. The student should follow the rules given in previous problems.

PLATE IV.

The patterns for the transition piece U and the 3-pieced elbow V constitute Plate IV.

To obtain the patterns for the transition piece U, use the description given in connection with Figs. 14 and 15, but lay off the diagram of triangles similar to the directions given in connection with Figs. 78 to 81. The patterns for the 3-pieced elbow V should be developed as described in connection with Figs. 46 and 47. These two problems U and V should be carefully laid out on similar sized plate as previously used. Care should be taken not to allow any of the patterns to come within $\frac{1}{4}$ inch of the margin line and place the patterns in such positions to make a neat appearance.

PLATE V.

The patterns of W and X, together with the pattern for the opening in Y, constitute this plate.

To obtain the pattern for the transition piece W, use the rule described in connection with Figs. 11 to 13, and for the pattern X use rules described in connection with Figs. 133 and 134. In this case we make no allowance for the thickness of the metal as shown in those figures, but assume that we are using ordinary gauge metal. For the pattern for the opening in the main pipe Y use rules given in connection with Figs. 134 and 136, and also omit allowing for heavy material.

EXAMINATION PLATES.

Plates III to V, inclusive, constitute the Examination for this Instruction Paper. As above mentioned, Plates IV and V are drawn by the student himself, and therefore no reproduced plates are sent. The date, student's name and address, and the plate number should be lettered on each plate in inclined Gothic capitals.

SKYLIGHT WORK*

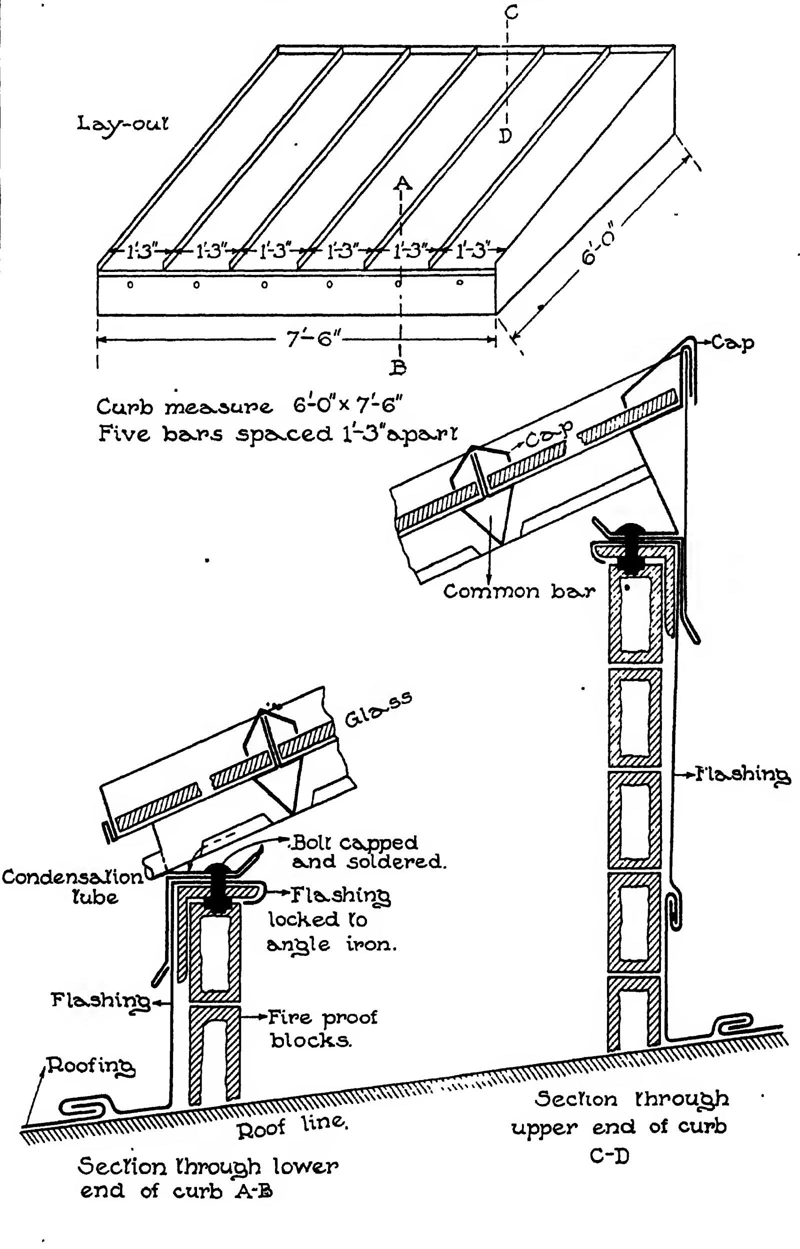
The upper illustration shows the layout of a flat pitched skylight whose curb measures 6′–0″×7′–6″, the run of the rafter or length of the glass being 6′ 0″ on a horizontal line. Five bars are required, making the glass 15 inches wide A working section through AB and CD is shown below.

It will be noticed in the section through AB that the flashing is locked to the roofing and flanged around the inside of the angle iron construction; over this the curb of the skylight rests, bolted through the angle iron as shown, the bolt being capped and soldered to avoid leakage.

The same construction is used in the section through CD, with the exception, that when the flashing cannot be made in one piece, a cross lock is placed in the manner indicated, over the fireproof blocks.

* The illustration referred to will be found on the back of this page.

CONSTRUCTION DRAWING SHOWING LAYOUT OF FLAT SKYLIGHT AND METHOD OF FASTENING FLASHING ON ANGLE IRON CONSTRUCTION.



FOR EXPLANATION OF THIS PROBLEM SEE BACK OF PAGE

SHEET METAL WORK

PART III

SKYLIGHT WORK

Where formerly skylights were constructed from wrought iron or wood, to-day in all the large cities they are being made of galvanized sheet iron and copper. Sheet metal skylights, having by their peculiar construction lightness and strength, are superior to iron and wooden lights; superior to iron lights, inasmuch as there is hardly any expansion or contraction of the metal to cause leaks or breakage of glass; and superior to wooden lights, because they are fire, water and condensation-proof, and being less clumsy, admit more light.

The small body of metal used in the construction of the bar and curb and the provisions which can be made to carry off the inside condensation, make sheet metal skylights superior to all others constructed from different material.

CONSTRUCTION

The construction of a sheet metal skylight is a very simple matter, if the patterns for the various intersections are properly developed. For example, the bar shown in Fig. 145 consists of a piece of sheet metal having the required stretchout and length, and bent by special machinery, or on the regular cornice brake, into the shape shown, which represents strength and rigidity with the least amount of weight. A A represent the condensation gutters to receive the condensation from the inside when the warm air strikes against the cold surface of the glass, while B B show the rabbets or glass-rest for the glass.

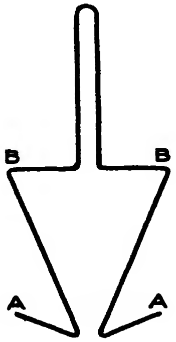


Fig. 145.

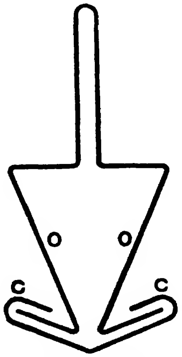


Fig. 146.

In Fig. 146, C C is a re-enforcing strip, which is used to hold the

two walls O O together and impart to it great rigidity. When skylight bars are required to bridge long spans, an internal core is made of sheet metal and placed as shown at A in Fig. 147, which adds to its weight-sustaining power. In this figure B B shows the glass laid on a bed of putty with the metal cap C C C, resting snugly against the glass, fastened in position by the rivet or bolt D D. Where a very large span is to be bridged a bar similar to that shown in Fig. 148 is used. A heavy core plate A made of $\frac{1}{4}$-inch thick metal is used, riveted or bolted to the bar at B and B. In construction, all the various bars terminate at the curb shown at A B C in Fig. 149, which is fastened to the wooden frame D E.

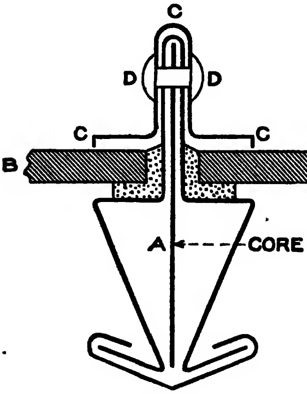


Fig. 147.

The condensation gutters C C in the bar *b*, carry the water into the internal gutter in the curb at *a*, thence to the outside through holes provided for this purpose at F F. In Fig. 150 is shown a sectional view of the construction of a double-pitched skylight. A shows the ridge bar with a core in the center and cap attached over the glass. B shows the cross bar or clip which is used in large skylights where it is impossible to get the glass in one length, and where the glass must be protected and leakage prevented by means of the cross bar, the gutter of which conducts the water into the gutter of the main bar, thence outside the curb as before explained. C is the frame generally made of wood or angle iron and covered by the metal roofer with flashing as shown at F. D shows the skylight bar with core showing the glass and cap in position. E is the metal curb against which the bars terminate, the condensation being let out through the holes shown.

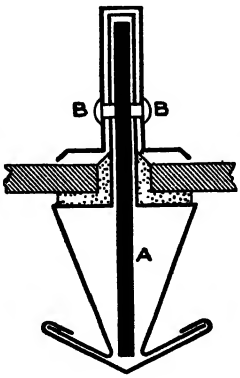


Fig. 148.

In constructing pitched skylights having double pitch, or being hipped, the pitch is usually one-third. In other words it is one-third

of the span. If a skylight were 12 feet wide and one-third pitch were required, the rise in the center would be one-third of 12, or 4 feet. When a flat skylight is made the pitch is usually built in the wood or iron frame and a flat skylight laid over it. The glass used in the construction of metallic skylights is usually $\frac{1}{4}$-inch rough or ribbed glass; but in some cases heavier glass is used.

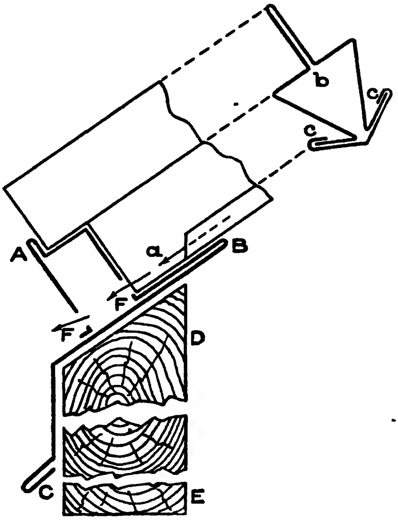


Fig. 149

If for any reason it is desired to know the weight of the various thickness of glass, the following table will prove valuable.

Weight of Rough Glass Per Square Foot.

Thickness in inches.	$\frac{1}{8}$.	$\frac{3}{16}$.	$\frac{1}{4}$.	$\frac{3}{8}$.	$\frac{1}{2}$.	$\frac{5}{8}$.	$\frac{3}{4}$.	1.
Weight in pounds.	2.	$2\frac{1}{2}$.	$3\frac{1}{2}$.	5.	7.	$8\frac{1}{2}$.	10.	$12\frac{1}{2}$.

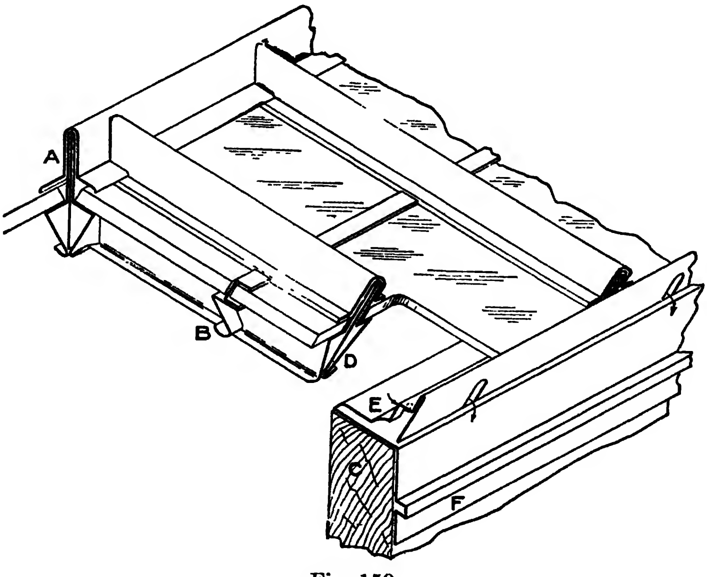


Fig. 150.

SHOP TOOLS

In the smaller shops the bars are cut with the hand shears and formed up on the ordinary cornice brake. In the larger shops, the strips required for the bars or curbs are cut on the large squaring shears, and the miters on the ends of these strips are cut on what is known as a miter cutter. This machine consists of eight foot presses on a single table, each press having a different set of dies for the purpose of cutting the various miters on the various bars. The bars are then formed on what is known as a Drop Press in which the bar can be formed in two operations to the length of 10 feet.

METHOD EMPLOYED IN OBTAINING THE PATTERNS

The method to be employed in developing the patterns for the various skylights is by parallel lines. If, however, a dome, conservatory or circular skylight is required, the blanks for the various curbs, bars, and ventilators, are laid out by the rule given in Sheet Metal Work, Part IV, under "Circular Work".

VARIOUS SHAPES OF BARS

In addition to the shapes of bars shown in Figs. 145 to 148 inclusive, there is shown in Fig. 151 a plain bar without any condensation gutters, the joint being at A. B B represents the glass resting on the rabbets of the bar, while C shows another form of cap which covers

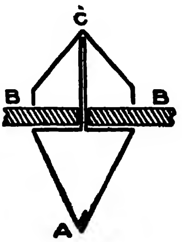


Fig. 151.

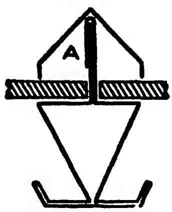


Fig. 152.

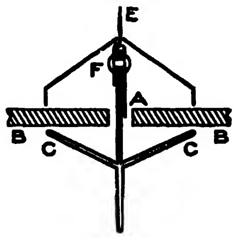


Fig. 153.

the joint between the bar and glass. Fig. 152 gives another form of bar in which the condensation gutters and bar are formed from one piece of metal with a locked hidden seam at A. Fig. 153 shows a bar on which no putty is required when glazing. It will be noticed that it is bent from one piece of metal with the seam at A, the glass B B resting on the combination rabbets and gutters C C. D is the cap which is fastened by means of the cleat E. These cleats are cut about ½-inch wide from soft 14-oz. copper, and riveted to the top of the bar

at F; then a slot is cut into the cap D as shown from *a* to *b* in Fig. 154; then the cap is pressed firmly onto the glass and the cleat E turned down which holds the cap in position.

When a skylight is constructed in which raising sashes are required, as shown in Fig. 155, half bars are required at the sides A and B, while the bars on each side of the sash to be raised are so constructed that a water-tight joint is obtained when closed. This is shown in Fig. 156, which is an enlarged section through A B in Fig. 155. Thus in Fig. 156, A A represents the two half bars with condensation gutters as shown, the locked seam taking place at B B. C C represent the two half bars for the raising sash with the caps D D attached to same, as shown, so that when the sash C C is closed, the caps

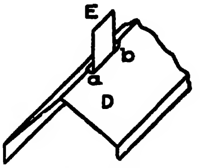


Fig. 154.

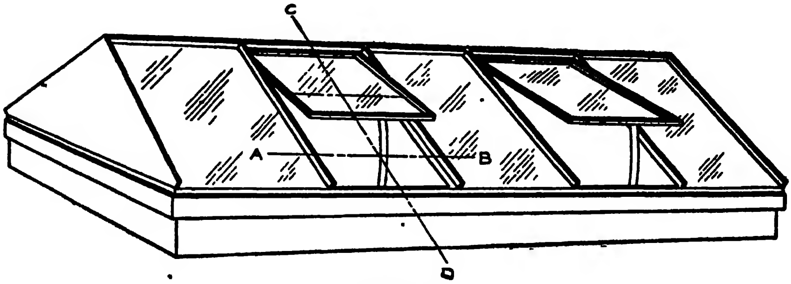


Fig. 155.

D D cover the joint between the glass E E and the stationary half bars. F F are the half caps soldered at *a a* to the bars C C which protect the joints between the glass H H and the bars C C.

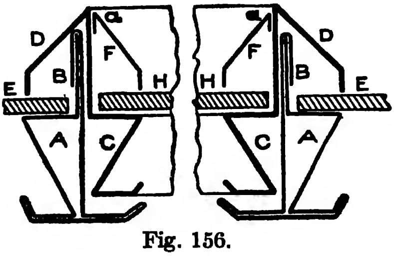


Fig. 156.

VARIOUS SHAPES OF CURBS

In Figs. 157, 158 and 159 are shown a few shapes of curbs which are used in connection with flat skylights. A in Fig. 157 shows the curb for the three sides of a flat skylight, formed in one piece with a joint at B, while C shows the cap, fastened as previously described. "A" shows the height at the lower end of the curb, which is made as high as the glass is thick and allows the water to run over. In Fig. 158, A is

another form of skylight formed in one piece and riveted at B; *a* shows the height at the lower end. In the previous figures the frame on which the metal curb rests is of wood, while in Fig. 159 the frame is

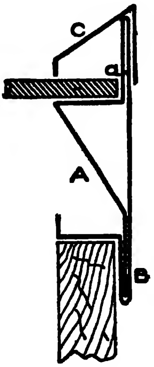


Fig. 157.

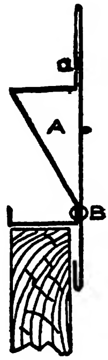


Fig. 158.

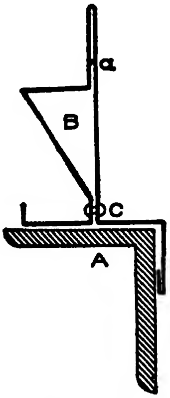


Fig. 159.

of angle iron shown at A. In this case the curb is slightly changed as shown at B; bent in one piece, and riveted at C. In Figs. 160, 161, and 162 are shown various shapes of curbs for pitched skylights in addition to that shown in Fig. 149. A in Fig. 160 shows a curb formed in one piece from *a* to *b* with a condensation hole or tube shown at B.

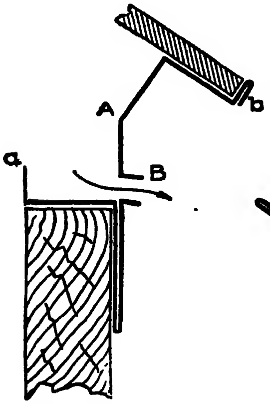


Fig. 160.

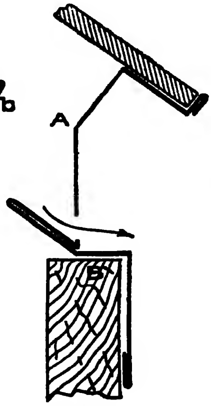


Fig. 161.

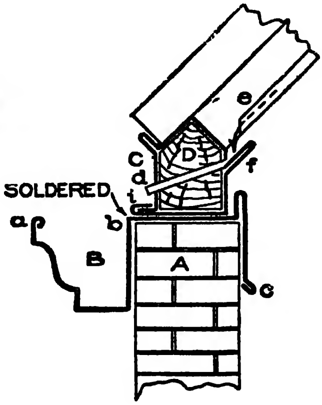
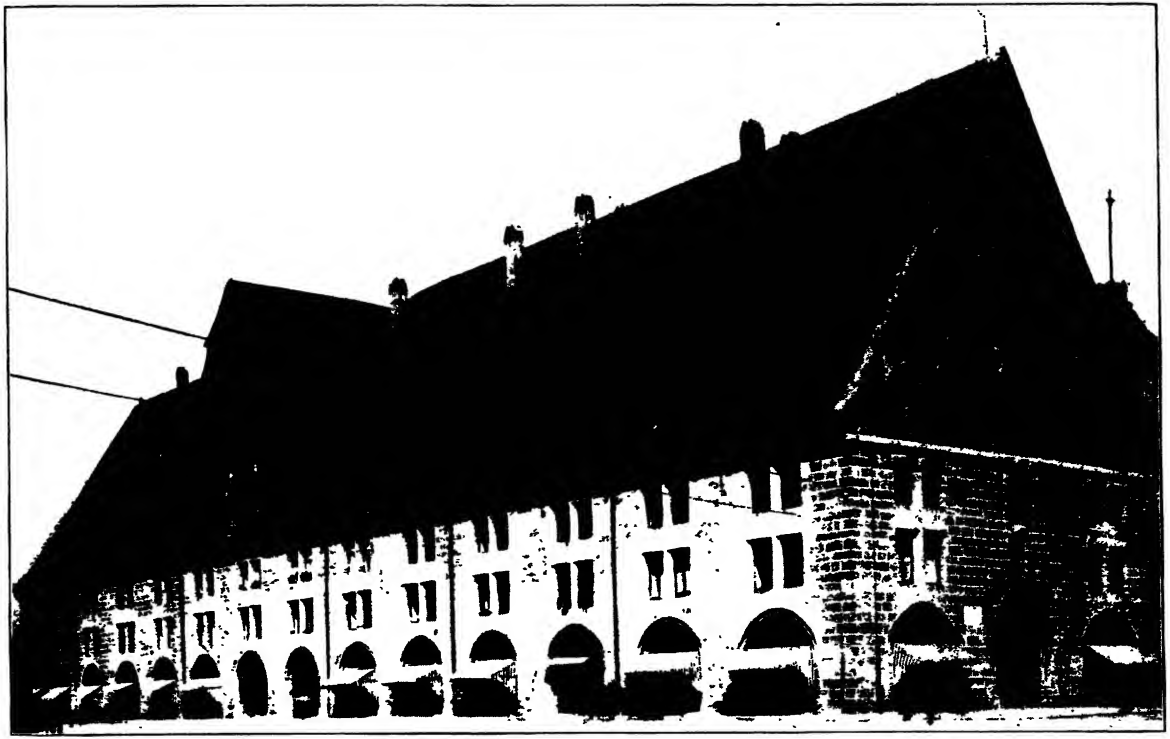


Fig. 162.

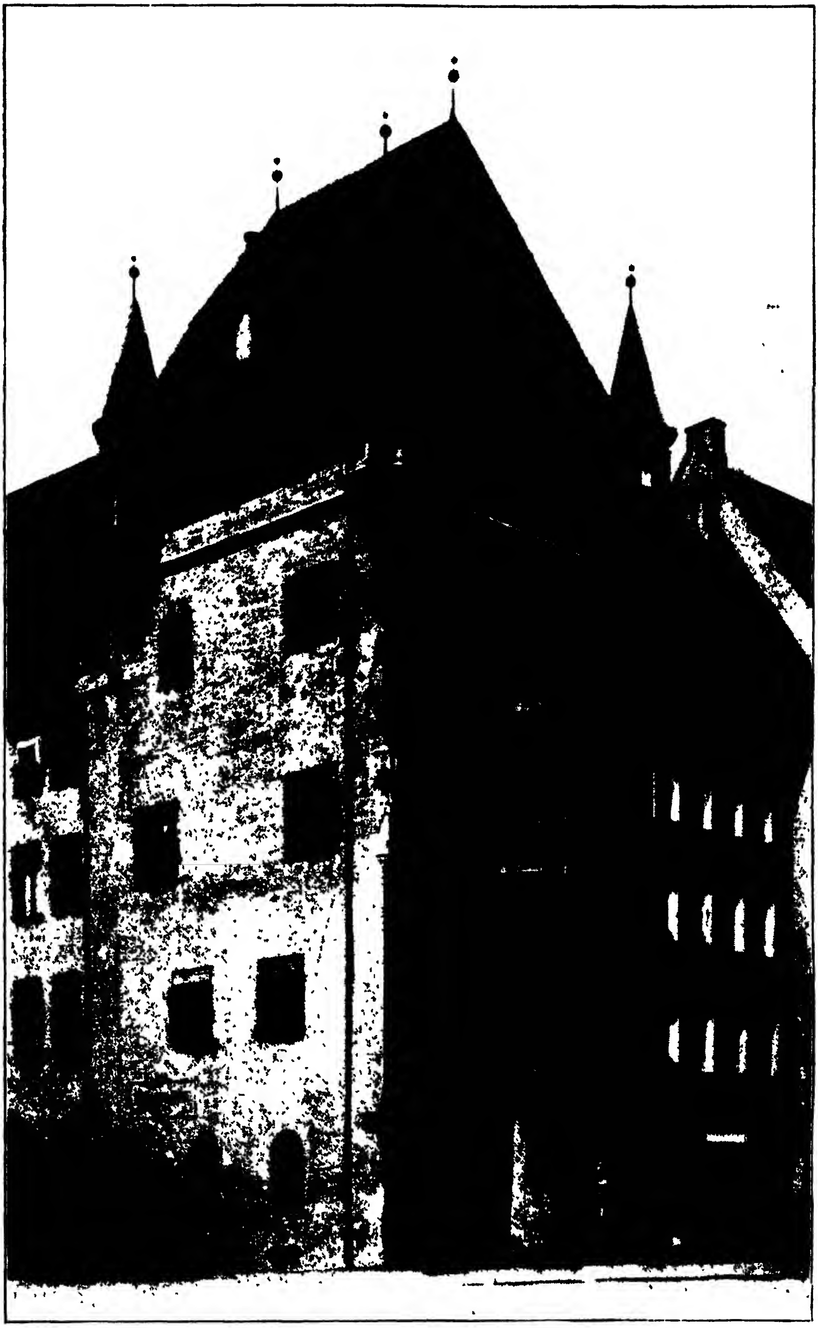
In Fig. 161 is shown a slightly modified shape A, with an offset to rest on the curb at B. When a skylight is to be placed over an opening whose walls are brick, a gutter is usually placed around the wall, as



MAUTH GEBAUDE, NÜRNBERG, GERMANY

Hans Beheim, Architect.

Built in 1498-1502 The Steep Tile Roof is an Imposing Feature. Note the Decorative Treatment of the Gable End.



THE "NASSAUER HAUS" IN NÜRNBERG, GERMANY

Built at the End of the Thirteenth Century. Railing of Gallery underneath Red-Tiled Roof is Decorated with Coats of Arms. In the Niche over the Fountain at the Lower Right, is a Statue of King Adolf von Nassau.

shown in Fig. 162, in which A represents a section of the wall on which a gutter, B, is hung, formed from one piece of metal, as shown from *a* to *b* to *c*. On top of this the metal curb C is soldered, which is also formed from one piece with a lock seam at *i*. To stiffen this curb a wooden core is slipped inside as shown at D. From the inside condensation gutter *f* a 14-oz. copper tube runs through the curb, shown at *d*. The condensation from the gutter *e* in the bar, drips into the gutter *f*, out of the tube *d*, into the main gutter B, from which it is conveyed to the outside by a leader.

In Fig. 163 is shown an enlarged section of a raising sash, taken through C D in Fig. 155. A in Fig. 163 shows the ridge bar, B the lower curb and C D the side sections of the bars explained in connection with Fig. 156. E F in Fig. 163 shows the upper frame of the raising sash, fitting onto the half ridge bar A. On each raising sash, at the upper end two hinges H are riveted at E and I, which allow the sash to raise or close by means of a cord, rod, or gearings. J K shows the lower frame of the sash fitting over the curb B. Holes are punched at *a* to allow the condensation to escape into *b*, thence to the outside through C. Over the hinge H a hood or cap is placed which prevents leakage. Fig. 164 shows a section through A B in Fig. 167 and represents a hipped skylight having one-third pitch. By a skylight of one-third pitch is meant a skylight whose altitude or height A B, is equal to one-third of the span C D. If the skylight was to have a pitch of one-fourth or one-fifth, then the altitude A B would equal one-fourth or one-fifth respectively of the span C D.

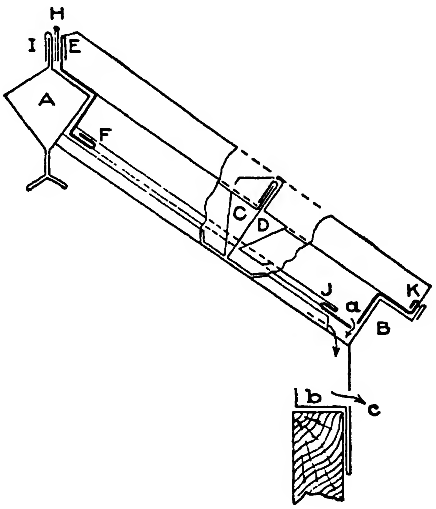


Fig. 163.

The illustration shows the construction of a hipped skylight with ridge ventilator which will be briefly described. C D is the curb; E E the inside ventilator; F F the outside ventilator forming a cap over the

glass at *a*. G shows the hood held in position by two cross braces H. J represents a section of the common bar on the rabbets of which the glass K K rests. L shows the condensation gutters on the bar J,

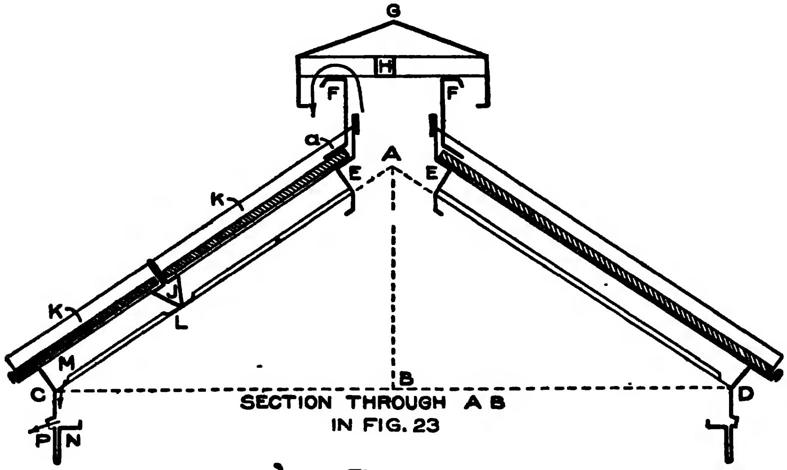


Fig. 164.

which are notched out as shown at M, thus allowing the drip to enter the gutter N and discharge through the tube P. The foul air escapes under the hood G as shown by the arrow.

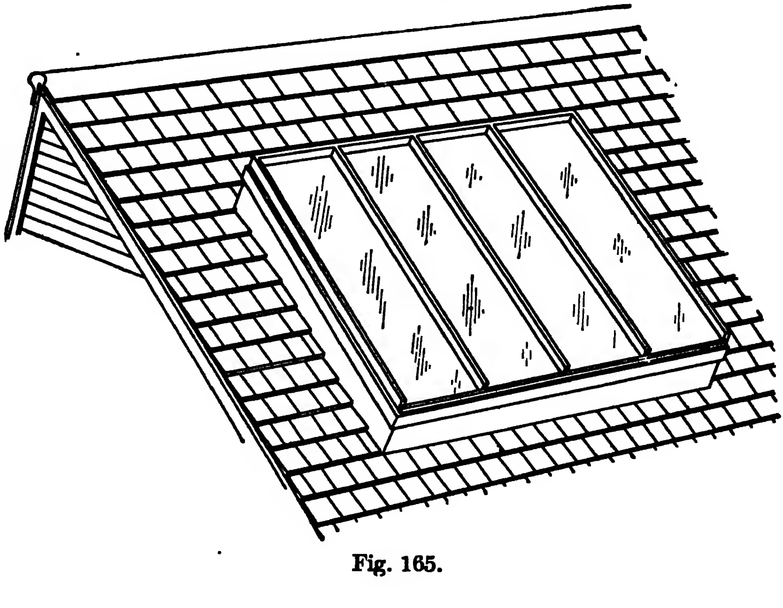


Fig. 165.

VARIOUS STYLES OF SKYLIGHTS

In Fig. 165 is shown what is known as a single-pitch light, and is placed on a curb made by the carpenter which has the desired pitch.

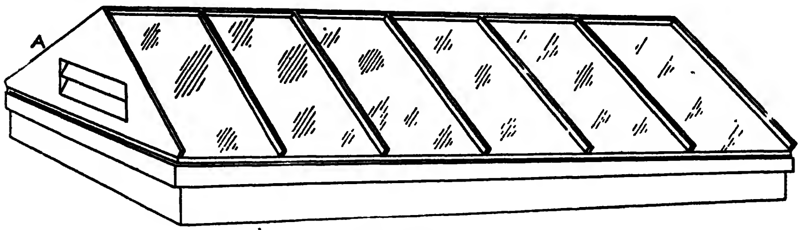


Fig. 166.

These skylights are chiefly used on steep roofs as shown in the illustration, and made to set on a wooden curbs pitching the same as the

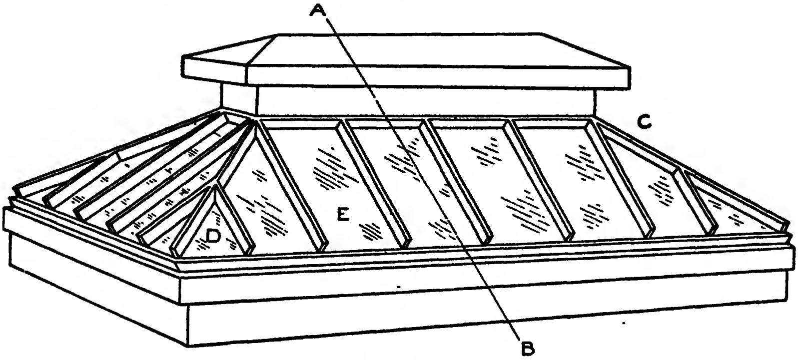


Fig. 167.

roof, the curb first being flashed. Ventilation is obtained by raising one or more lights by means of gearings, as shown in Fig. 155.

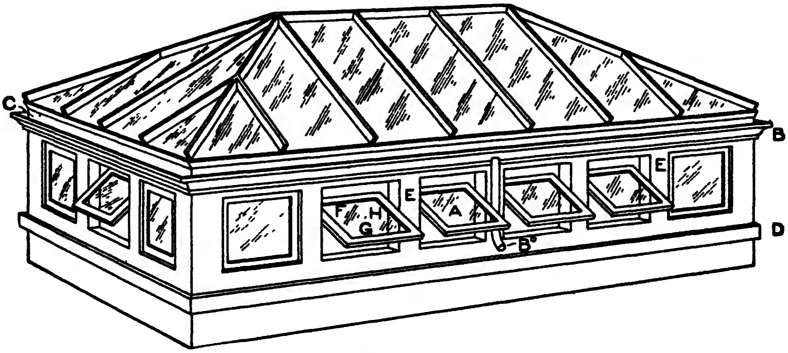


Fig. 168.

Fig. 166 shows a double-pitch skylight. Ventilation is obtained by placing louvres at each end as shown at A. Fig. 167 shows a skylight with a ridge ventilator. The corner bar C is called the hip bar; the small bar D, mitering against the corner bar, is called the jack bar, while E is called the common bar. Fig. 168 illustrates a hip monitor skylight with glazed opening sashes for ventilation. These sashes can be opened or closed separately, by means of gearings similar to those shown in Fig. 177 In Fig. 169 is shown the method of raising

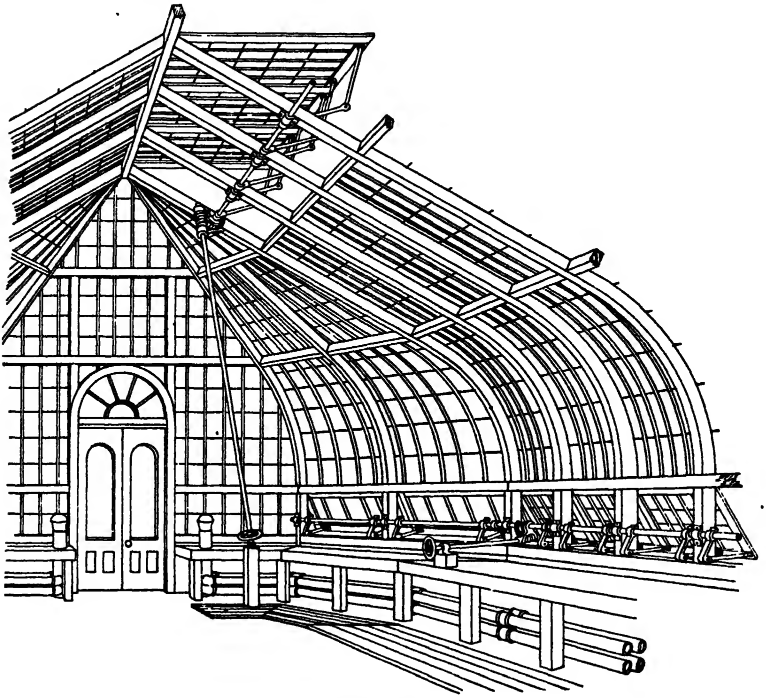


Fig. 169.

sashes in conservatories, greenhouses, etc., the same apparatus being applicable to both metal and wooden sashes. Fig. 170 shows a view of a photographer's skylight; if desired, the vertical sashes can be made to open.

In Fig. 171 is shown a flat extension skylight at the rear of a store or building. The upper side and ends are flashed into the brick work and made water-tight with waterproof cement, while the lower side rests on the rear wall to which it is fastened. In some cases the rear

gutter is of cast iron, put up by the iron worker, but it is usually made of No. 22 galvanized iron, or 20-oz. cold-rolled copper. To receive the bottom of the gutter and skylight, the wall should be covered by a wooden plate A, Fig. 172, about two inches thick, and another plank set edgeways flush with the inside of the wall, as shown at B. The two planks are not required when a cast iron gutter is used.

Fig. 173 shows a hipped skylight without a ridge ventilator, set on a metal curb in which louvres have been placed. These louvres may be made stationary or movable. When made movable, they are

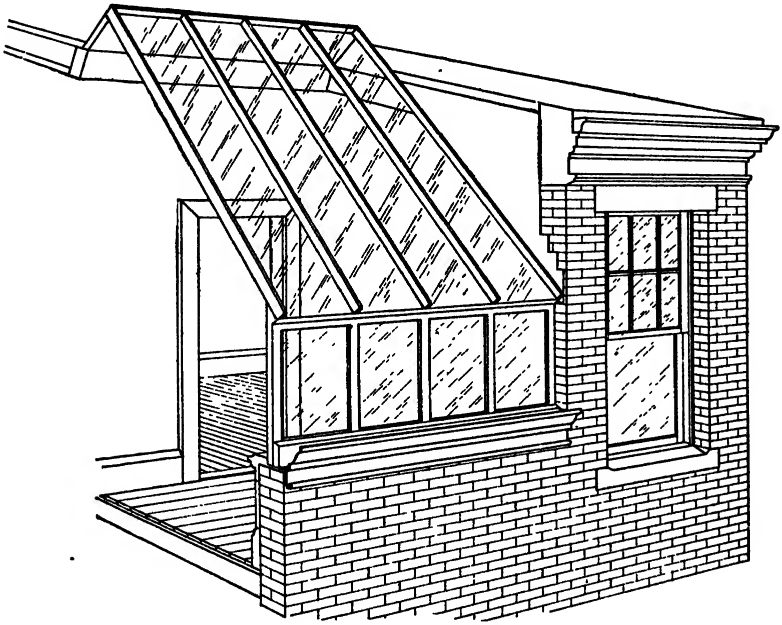


Fig. 170.

constructed as shown in Fig. 174, in which A shows a perspective view, B shows them closed, and C open. They are operated by the quadrants attached to the upright bars *a* and *b*, which in turn are pulled up and down by cords or chains worked from below. When a skylight has a very long span, as in Fig. 175, it is constructed as shown in Fig. 176, in which A represents a T-beam which can be trussed if necessary. This construction allows the water to escape from the bottom of the upper light to the outside of the top of the lower skylight, the curb C of the upper light fitting over the curb B of the lower light.

In Fig. 177 is shown the method of applying the gearings. A shows the side view of the metal or wooden sash partly opened, B the

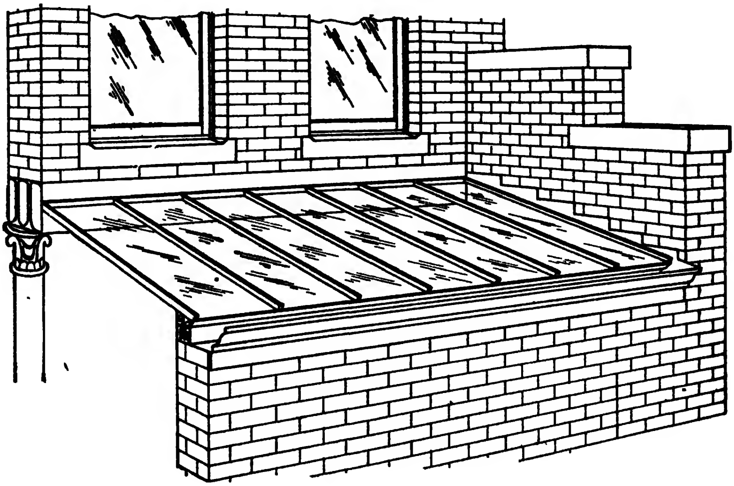


Fig. 171.

end of the main shaft, and C the binder that fastens the main shaft to the upright or rafter. D shows the quadrant wheel attached to main shaft and E is the worm wheel, geared to the quadrant D, communicating motion to the whole shaft. F is a hinged arm fastened to the main shaft B and hinged to the sash. By turning the hand-wheel the sash can be opened at any angle.

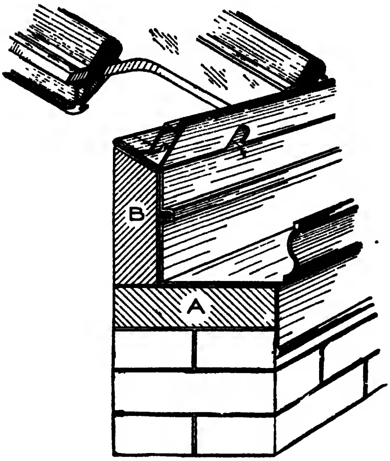


Fig. 172.

DEVELOPMENT OF PATTERNS FOR A HIPPED SKYLIGHT

The following illustrations and text will explain the principles involved in developing the patterns for the ventilator, curb, hip bar, common bar, jack bar, and cross bar or clip, in a hipped skylight. These principles are also applicable to any other form of light, whether flat, double-pitch, single-pitch, etc.

In Fig. 178 is shown a half section, a quarter plan, and a diagonal elevation of a hip bar, including the patterns for the curb, hip, jack, and common bars. The method of making these drawings will be explained in detail, so that the student who pays close attention

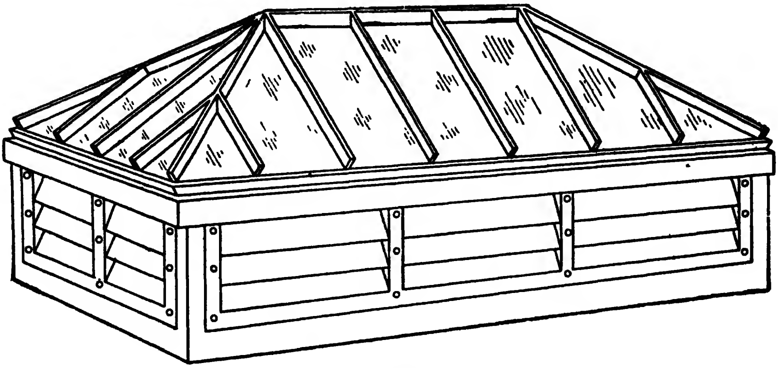


Fig. 173

will have no difficulty in laying out any patterns no matter what the pitch of the skylight may be, or what angle its plan may have.

First draw any center line as A B, at right angles to which lay off C 4′, equal to 12 inches. Assuming that the light is to have one-third

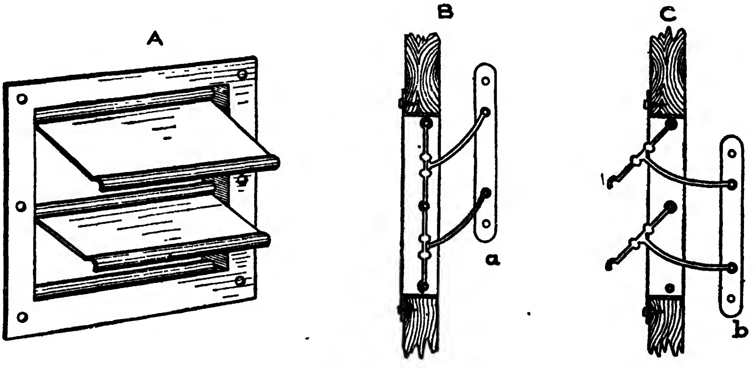


Fig. 174.

pitch, then make the distance C D equal to 8 inches which is one-third of 24 inches, and draw the slant line D 4.′ At right angles to D 4′ place a section of the common bar as shown by E, through which draw lines parallel to D 4′, intersecting the curb shown from *a* to *f* at the bottom and the inside section of the ventilator from F to G at the top. At

pleasure draw the section of the outside vent shown from *h* to *l* and the hood shown from *m* to *p*. X represents the section of the brace resting on *i j* to uphold the hood resting on it in the corner *o*. The condensa-

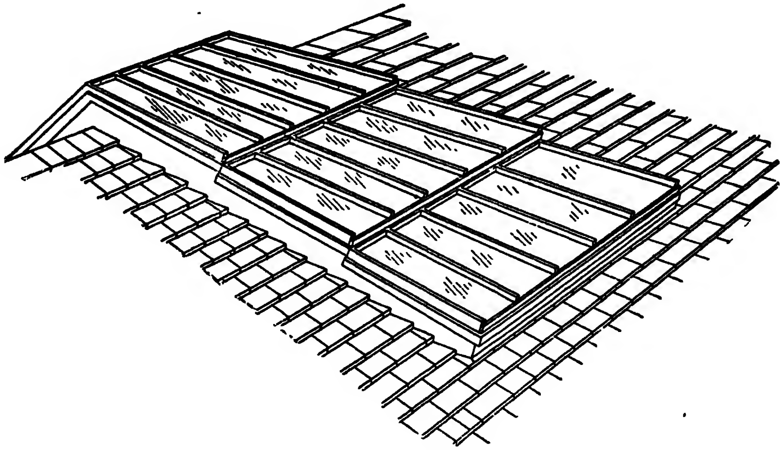


Fig. 175

tion gutters of the common bar E are cut out at the bottom at 5′ 6′ which allows the drip to go into the gutter *d e f* of the curb and pass out of the opening indicated by the arrow. Number the corners of each half of the common bar section E as shown, from 1 to 6 on each side, through which draw lines parallel to D 4′ until they intersect the curb at the bottom as shown by similar numbers 1′ to 6′, and the inside ventilator at the top by similar figures 1″ to 6″. This completes the one half-section of the skylight. From this section the pattern for the common bar can be obtained without the plan, as follows:

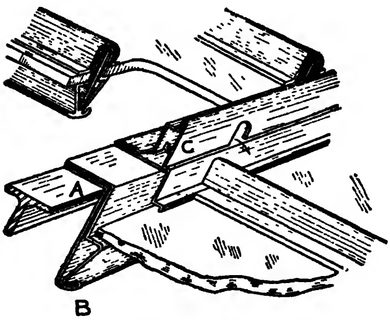


Fig. 176.

At right angles to D 4′ draw the line I J upon which place the stretchout of the section E as shown by similar figures on I J. Through these small figures, and at right angles to I J, draw lines, and intersect them by lines drawn at right angles to D 4′ from similarly numbered intersections 1′ to 6′ on the curb and 1″ to 6″ on the inside ventilator. Trace a line through points thus obtained; then A¹ B¹ C¹ D¹ will be the

pattern for the common bar in a hipped skylight. The same method would be employed if a pattern were developed for a flat or a double-pitch light. From this same half section the pattern for the curb is developed by taking the stretchout of the various corners in the curb, *a b* 3′ 4′ *c d e* and *f*, and placing them on the center line A B as shown by similar letters and figures. Through these divisions and at right angles to A B draw lines which intersect with lines drawn at right angles to C 4′ from similar points in the curb section *a f*. Trace a line through points thus obtained; then E^1 F^1 *f a* will be the half pattern for the curb shown in the half section. V represents the condensation hole to be punched into the pattern between each light of glass in the skylight. As the portion *c d* turns up on *c* 4′, use *r* as a center, and with

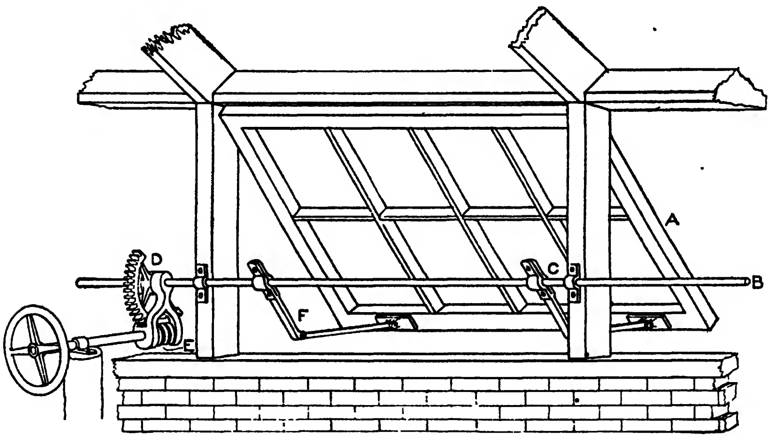


Fig. 177.

the radius *r s* strike the semicircle shown. Above this semicircle punch the hole V.

Before the patterns can be obtained for the hip and jack bars, a quarter plan view must be constructed which will give the points of intersections between the hip bar and curb, between the hip bar and vent, or ridge bar, and between the hip and jack bar. Therefore, from any point on the center line A B as K, draw K L at right angles to A B. As the skylight forms a right angle in plan, draw from K, at an angle of 45°, the hip or diagonal line K 1°. Take a tracing of the common bar section E with the various figures on same, and place it on the hip line K 1° in plan so that the points 1 4 come directly on the hip as shown by E^1. Through the various figures draw lines parallel to K 1°

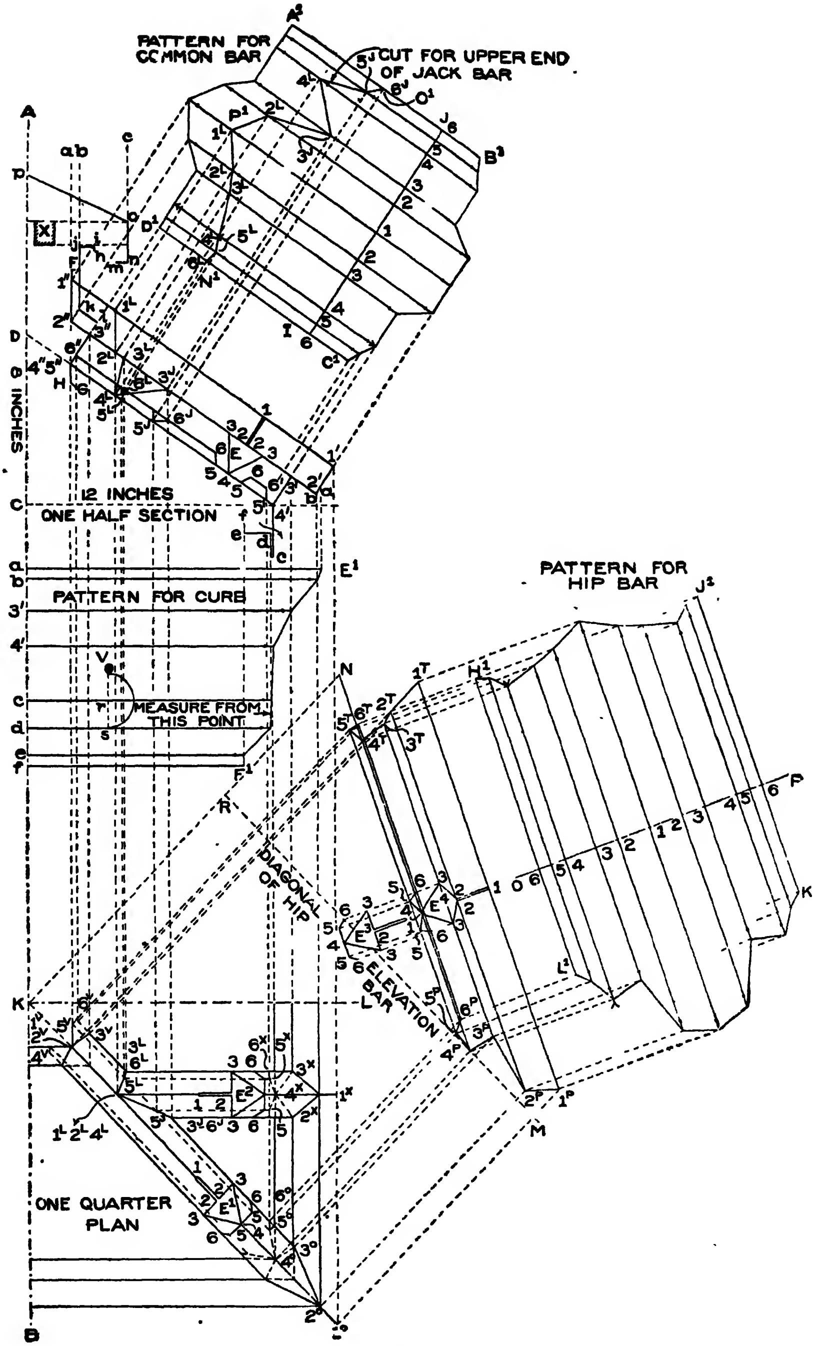

PATTERN FOR COMMON BAR
CUT FOR UPPER END OF JACK BAR
8 INCHES
12 INCHES
ONE HALF SECTION
PATTERN FOR CURB
MEASURE FROM THIS POINT
PATTERN FOR HIP BAR
DIAGONAL OF HIP
ELEVATION BAR
ONE QUARTER PLAN

Fig. 178.

one-half of which are intersected by vertical lines drawn parallel to A B from similar points of intersection 1′ to 6′ on the curb, and 1″ to 6″ on the ventilator in the half section, as shown respectively in plan by intersections 1° to 6° and 1^{V} to 6^{V}. Below the hip line K 1° trace the opposite intersection as shown. It should be understood that the section E^1 in plan does not indicate the true profile of the hip bar (which must be obtained later), but is only placed there to give the horizontal distances in plan. In laying out the work in practice to full size, the upper half intersection of the hip bar in plan is all that is required. It will be noticed that the points of intersections in plan and one half section have similar numbers, and if the student will carefully follow each point the method of these projections will become apparent.

Having obtained the true points of intersections in plan the next step is to obtain a diagonal elevation of the hip bar, from which a true section of the hip bar and pattern are obtained. To do this draw any line as R M parallel to K 1°. This base line R M has the same elevation as the base line C 4′ has in the half section. From the various points 1° to 6° and 1^{V} to 6^{V} in plan, erect lines at right angles to K 1° crossing the line R M indefinitely. Now measuring in each and every instance from the line C 4′ in the half section take the various distances to points D 1″ 2″ 3″ 4″ 5″ and 6″ at the top, and to points 1′ 2′ 3′ 4′ 5′ and 6′ at the bottom, and place them in the diagonal elevation measuring in each and every instance from the line R M on the similarly numbered lines drawn from the plan, thus locating respectively the points N 1^T 2^T 3^T 4^T 5^T and 6^T at the top, and 1^P 2^P 3^P 4^P 5^P and 6^P at the bottom. Through the points thus obtained draw the miter lines 1^T to 6^T and 1^P to 6^P and connect the various points by lines as shown, which completes the diagonal elevation of the hip bar intersecting the curb and vent, or ridge. To obtain the true section of the hip bar, take a tracing of the common bar E or E^1 and place it in the position shown by E^3, being careful to place the points 1 4 at right angles to 1^T. 1^P as shown. From the various points in the section E^3 at right angles to 1^P 1^T draw lines intersecting similarly numbered lines in the diagonal elevation as shown from 1 to 6 on either side. Connect these points as shown; then E^4 will be the true profile of the hip bar. Note the difference in the two profiles; the normal E^3 and the modified E^4.

Having obtained the true profile E^4 the pattern for the hip bar is obtained by drawing the stretchout line O P at right angles 1^T 1^P.

Take the stretchout of the profile E^4 and place it on O P as shown by similar figures. Through these small figures and at right angles to O P draw lines which intersect by lines drawn at right angles to 1^T 1^P from similarly numbered points at top and bottom, thus obtaining the points of intersections shown. A line traced through the points thus obtained, as shown by H^1 J^1 K^1 L^1 will be the pattern for the hip bar.

For the pattern for the jack bar, take a tracing of the section of the common bar E and place it in the position in plan as shown by E^2 being careful to have the points 1 and 4 at right angles to the line 1^X 1°. It is immaterial how far the section E^2 is placed from the corner 2° as the intersection with the hip bar remains the same no matter how far the section is placed one way or the other. Through the various corners in the section E^2 draw lines at right angles to the line 1° 1^X intersecting one half of the hip bar on similarly numbered lines as shown by the intersections 1^L 2^L 3^L 4^L 5^L 6^L and 1^L 2^J 3^J 4^L 5^J and 6^J; also intersecting the curb in plan at points 1^X to 6^X. The intersection between the jack bar and curb in plan is not necessary in the development of the pattern as the lower cut in the pattern for the common bar is the same as the lower cut in the pattern for the jack bar. However, the intersection is shown in plan to make a complete drawing. At right angles to the line of the jack bar in plan, and from the various intersections with the hip bar, erect lines intersecting similarly numbered lines in the section as shown. Thus from the various intersections shown from 1^L to 6^L in plan, erect vertical lines intersecting the bar in the half section at points shown from 1^L to 6^L. In similar manner from the various points of intersections 3^J, 5^J, and 6^J in plan, erect lines intersecting the bar in the half section at points shown by 3^J 5^J 6^J. Connect these points in the half section, as shown, which represents the line of joint in the section between the hip and jack bars.

For the pattern for the upper cut of the jack bar, the same stretchout can be used as that used for the common bar. Therefore, at right angles to D 4′ and from the various intersections 1^L 2^L 3^L 4^L 5^L and 6^L draw lines intersecting similar numbered lines in the pattern for the common bar as shown by similar figures. In similar manner from the various intersections 3^J 5^J and 6^J in the one half section, draw lines at right angles to D 4′ intersecting similarly numbered lines in the pattern as shown by 3^J 5^J and 6^J. Trace lines from point to point, then the

cut shown from N^1 to P^1 will represent the miter for that part shown in plan from 2^L to 6^L, and the cut shown from P^1 to O^1 in the pattern will represent the cut for that part shown in plan from 2^L to 6^J. The lower cut of the jack bar remains the same as that shown in the pattern.

The half pattern for the end of the hood is shown in Fig. 179, and is obtained as follows: Draw any vertical line as A B, upon which place the stretchout of the section of the hood *m n o p* in Fig. 178, as shown by similar letters *m n o p* on A B in Fig. 179. At right angles to A B and through the small letters draw lines, making them equal in length, (measuring from the line A B) to points having similar letters in Fig. 178, also measuring from the center line A B. Connect points shown in Fig. 179, which is the half pattern for the end of the hood. For the half pattern for the end of the outside ventilator, take the

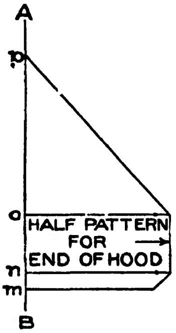


Fig. 179.

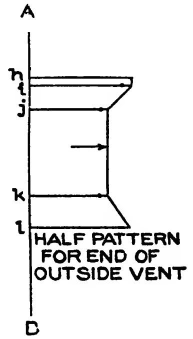


Fig. 180.

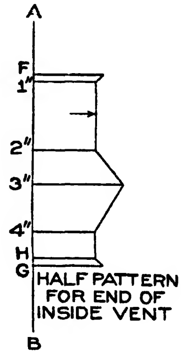


Fig. 181.

stretchout of *h i j k l* in Fig. 178 and place it on the vertical line A B in Fig. 180 as shown by similar letters, through which draw horizontal lines making them in length, measuring from A B, equal to similar letters in Fig. 178, also measuring from the center line A B. Connect the points as shown in Fig. 180 which is the desired half pattern. In Fig. 181 is shown the half pattern for the end of the inside ventilator, the stretchout of which is obtained from F 1″ 2″ 3″ 4″ H G in Fig. 178, the pattern being obtained as explained in connection with Figs. 179 and 180.

When a skylight is to be constructed on which the bars are of such lengths that the glass cannot be obtained in one length, and a cross bar or clip is required as shown by B, in Fig. 150, which miters against the main bar, the pattern for this intersecting cut is obtained as shown in

Fig. 182. Let A represent the section of the main bar, B the elevation of the cross bar, and C its section. Note how this cross bar is bent so that the water follows the direction of the arrow, causing no leaks because the upper glass *a* is bedded in putty, while the lower light *b* is capped by the top flange of the bar C (See Fig. 150). Number all of the corners of the section C as shown, from 1 to 8, from which points draw horizontal lines cutting the main bar A at points 1 to 8 as shown. At right angles to the lines in B draw the vertical line D E upon which

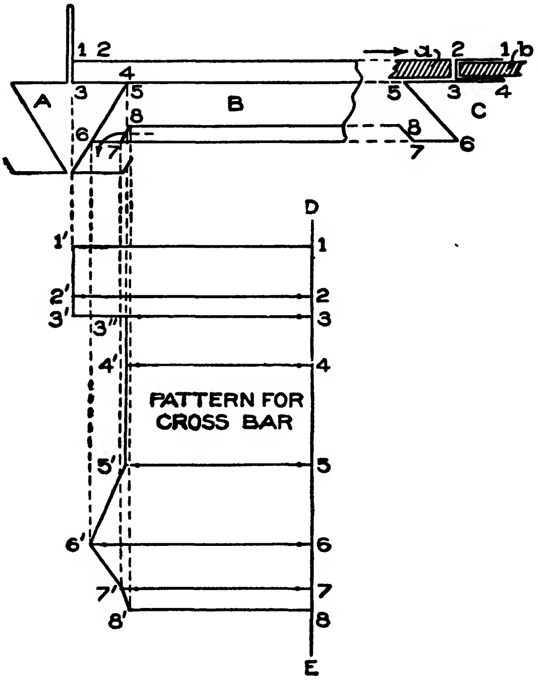


Fig. 182.

place the stretchout of the cross bar C, shown by similar figures, through which draw horizontal lines, intersecting them with lines drawn parallel to D E from similar numbered intersections against the main bar A, thus obtaining the points of intersections 1′ to 8′ in the pattern. Trace a line through points of intersections thus obtained which will be the pattern for the end cut of the cross bar.

In Fig. 183 is shown a carefully drawn working section of the turret sash shown in Fig. 168 at A. These sashes are operated by

means of cords, chains or gearings from the inside, the pivot on which they turn being shown by R S in Fig. 183. The method of obtaining the patterns for these sashes will be omitted, as they are only square and butt miters which the student will have no trouble in developing, providing he understands the construction. This will be made clear by the following explanation:

A B represents the upper part of the turret proper with a drip bent on same, as shown at B, against which the sashes close, and a double seam, as shown at A, which makes a tight joint, takes out the twist in bending, and avoids any soldering. This upper part A B is indicated by C in Fig. 168, over which the gutter B is placed as shown by X U Y in Fig. 183. C D represents the lower part of the turret proper or base, which fits over the wooden curb W, and is indicated by D in Fig. 168. E in Fig. 183 represents the mullion made from one piece of metal and double seamed at *a*. This mullion is joined to the top and bottom. The pattern for the top end of the mullion would simply show a square cut, while the pattern for the bottom would represent a butt miter against the slant line *i j*. Before forming up this mullion the holes should be punched in the sides to admit the pivot R S. These mullions are shown in position in Fig. 168 by E E, etc.

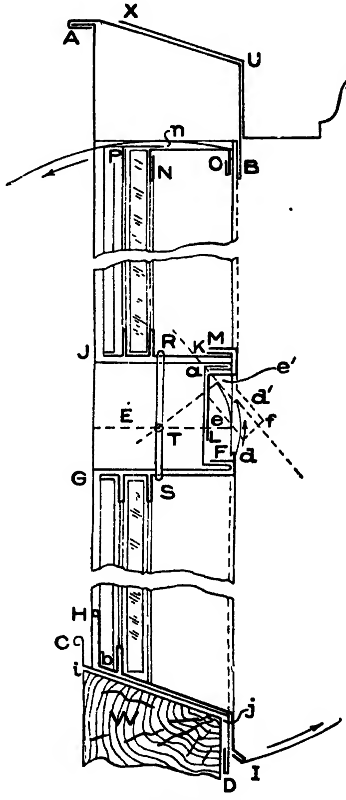


Fig. 183.

F G in Fig. 183 represents the section of the side of the sash below the pivot T. Notice that this lower half of the side of the sash has a lock attachment which hooks into the flange of the mullion E at F. While the side of the sash is bent in one piece, the upper half, above the pivot T, has the lock omitted as shown by J K. Thus when the sash opens, the upper half of the sides turn toward the inside as shown by

the arrow at the top, while the lower half swings outward as shown by the arrow at the bottom. When the lower half closes, it locks as shown at F, which makes a water-tight joint; but to obtain a water-tight joint for the upper half, a cap is used, partly shown by L M, into which the upper half of the side of the sash closes as shown at M. This cap is fastened to the upper part of the mullion E with a projecting hood *f* which is placed at the same angle as the sash will have when it is opened as shown by *e e'* and *d d'* or by the dotted lines.

The side of the sash just explained is shown in Fig. 168 at H. The pattern for the side of the sash has a square cut at the top, mitering with H I at the bottom, in Fig. 183, the same as a square miter. H I represents the section of the bottom of the sash. Note where the metal is doubled as at *b*, against which the glass rests in line with the rabbet on the side of the sash. A beaded edge is shown at H which stiffens it. This lower section is shown in Fig. 168 by G and has square cuts on both ends. N O in Fig. 183 shows the section of the top of the sash shown in Fig. 168 by F. The flange N in Fig. 183 is flush with the outside of the glass, thereby allowing the glass to slide into the grooves in the sides of the sash. After the glass is in position the angle P is tacked at *n*. A leader is attached to the gutter Y as shown by B° in Fig. 168. While the method of construction shown in Fig. 183 is generally employed, each shop has different methods; what we have aimed to give is the general construction in use, after knowing which, the student can plan his own construction to suit the conditions which are apt to arise.

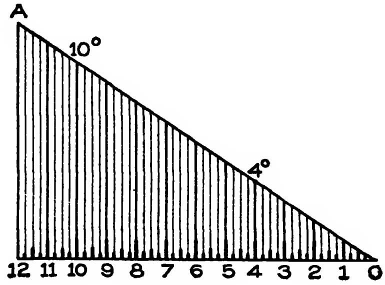
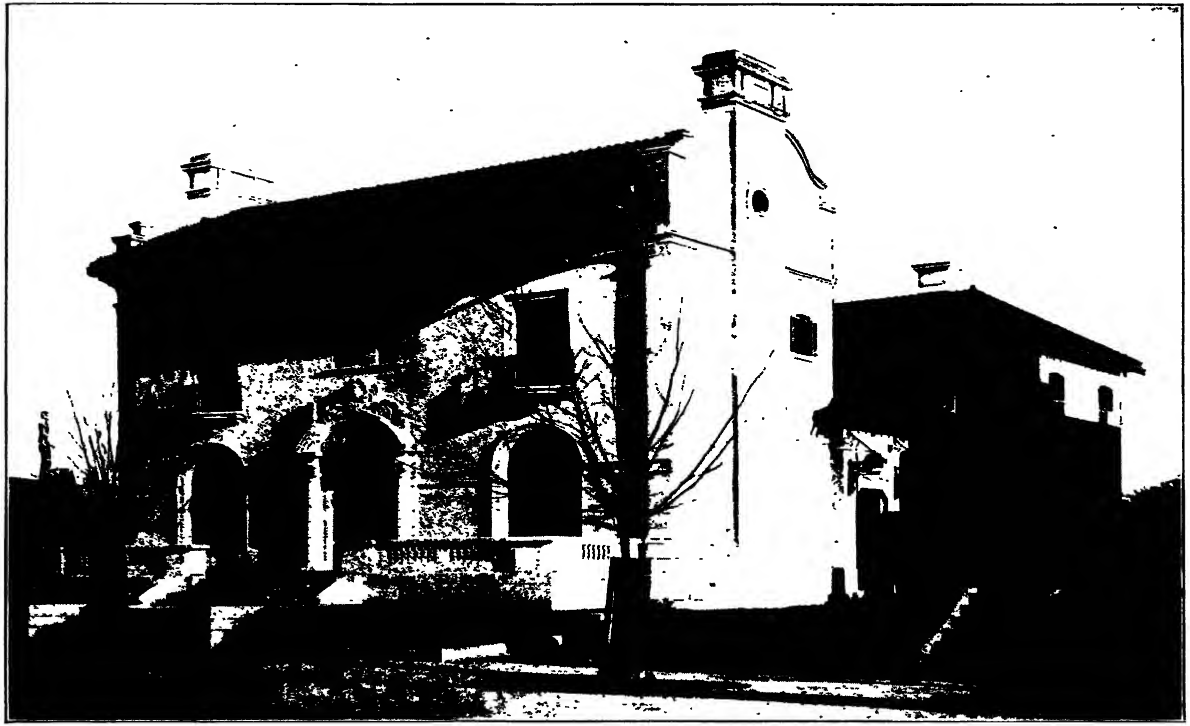


Fig. 184.

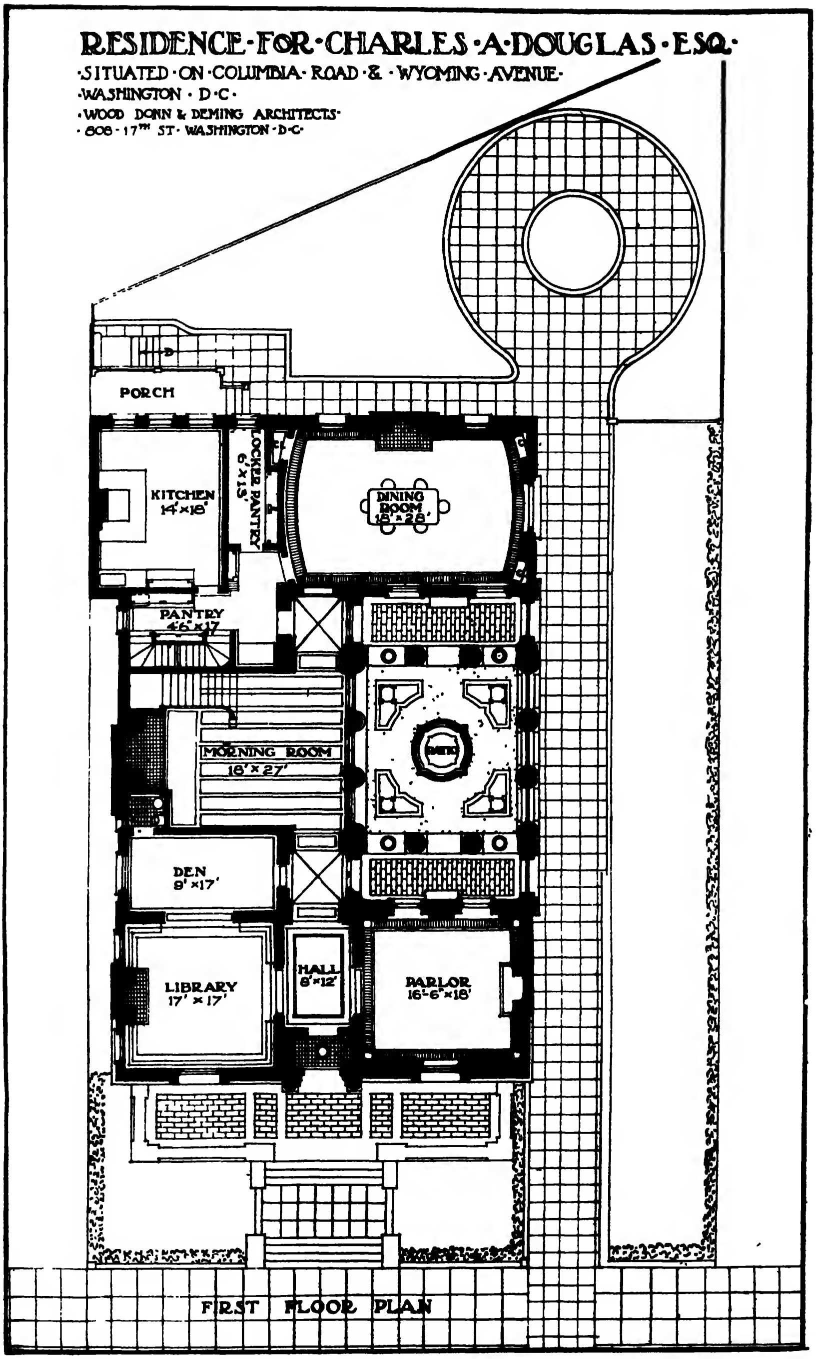
In the following illustrations, Figs. 184 to 187, it will be explained how to obtain the true lengths of the ventilator, ridge, hip, jack, and common bars in a hipped skylight, no matter what size the skylight may be. Using this rule only one set of patterns are required, as for example, those developed in connection with Figs. 178, 179, 180, and 181, which in this case has one-third pitch. If, however, a skylight was required whose pitch was different than one-third, a new set of patterns would have to be developed, to which the rule above mention-



HOUSE FOR CHAS. A. DOUGLAS, ESQ., WASHINGTON, D. C.

Wood, Donn & Deming, Architects, Washington, D. C.

An Interesting Example of an Open-Court Treatment Applied to a Narrow City Lot. Built of Stucco of White Marble Grit, with Wide, Projecting Eaves and Elaborate Supporting Rafters and Beams Stained a Dark Color Roofs of Red Tile. Plan Shown on Opposite Page



FIRST-FLOOR PLAN OF HOUSE FOR CHAS. A. DOUGLAS, ESQ., WASHINGTON, D. C.

Principal Rooms Grouped about an Open Court or Patio. Main Living Room, or "Morning Room," Looks Out upon Court through French Windows, which in Summer are Thrown Open, Providing Abundant Light and Air. On Second Floor, over Passageways on Each Side of Court, are Porches upon which Bedrooms Open, Thus Providing Comfort through the Hot Midsummer Nights. The Massing of Flowers and Vines on these Porches at the Parapet Line of the Tile-Covered Eaves, Adds a Most Pleasing Effect. Exterior Shown on Opposite Page.

ed would also be applicable for skylights of that particular pitch. Using this rule it should be understood that the size of the curb, or frame, forms the basis for all measurements, and that one of the lines or bends of the bar should meet the line of the curb as shown in Fig. 178, where the bottom of the bar E in the half section meets the line of the curb c 4′ at 4′, and the ridge at the top at 4′. Therefore when laying

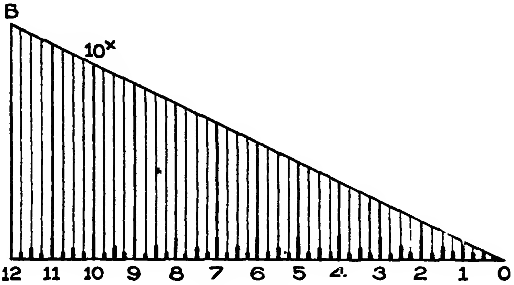


Fig. 185.

out the lengths of the bars, they would have to be measured on the line 4 of the bar E from 4′ to 4″ on the patterns, as will be explained as we proceed.

The first step is to prepare the triangles from which the lengths of the common and jack bars are obtained, also the lengths of the hip bars. After the drawings and patterns have been laid out full size according to the principles explained in Fig. 178, take a tracing of the triangle in the half section D C 4′ and place it as shown by A 12 O, in Fig. 184. Divide O 12, which will be 12 inches in full size, into quarter, half-inches, and inches, the same as on a 2-foot rule, as shown by the figures O to 12. From these divisions erect lines until they intersect the pitch A O which completes the triangle for obtaining the true lengths of jack and common bars for any size skylight. In similar manner take tracing of N R 4[P] in the diagonal elevation in Fig. 178 and place it as shown by B 12 O in Fig. 185. The length 12 O then becomes the base of the triangle for the hip bar in a skylight whose base of the triangle for the common and jack bars measures 12 inches

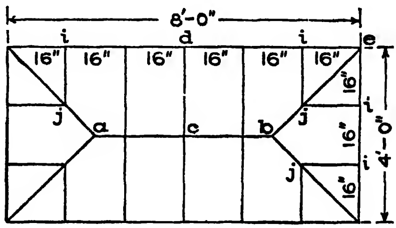


Fig. 186.

as shown in Fig. 184, the heights A 12 in Fig. 184 and B 12 in Fig. 185 being equal. Now divide 12 O in 12 equal spaces which will represent inches when obtaining the measurements for the hip bar. Divide each of the parts into quarter-inches as shown. From these devisions erect lines intersecting the hypothenuse or pitch line B O as shown.

To explain how these triangles are used in practice, Figs. 186 and 187 have been prepared, showing respectively a skylight without and with a ventilator whose curb measures 4 ft. x 8 ft. Three rules are used in connection with the triangles in Figs. 184 and 185, the comprehension of which will make clear all that follows.

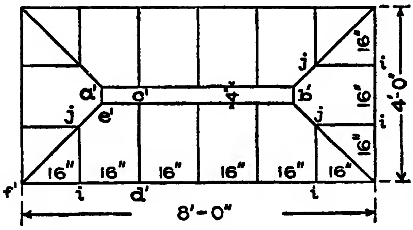


Fig. 187.

Rule 1. To obtain the length of the ridge bar in a skylight without a ventilator, as in Fig. 186, deduct the short side of the frame or curb from the long side.

Example: In Fig. 186, take 8 feet (long side of frame) — 4 feet (short side of frame) = 4 feet (length of ridge bar *a b*).

Rule 2. To find the length of the ventilator in a skylight deduct the short side of the frame from the long side and add the width of the desired ventilator (in this case 4 inches, as shown in Fig. 187).

Example: In Figure 187 take 8 feet (long side of frame) — 4 feet (short side of frame) = 4 feet. 4 feet + 4 inches (width of inside ventilator) = 4 feet 4 inches, (length of inside ventilator *a' b'*). To find the size of the outside ventilator *h l* and hood *m p* in Fig. 178 simply add twice the distance *a b* and *a c* respectively to the above size, 4 inches, and 4 feet 4 inches, which will give the widths and lengths of the outside vent and hood.

Rule 3. To find the lengths of either common or hip bar (in any size skylight) deduct the width of the ventilator, if any, from the length of the shortest side of frame and divide the remainder by two. Apply the length thus obtained on the base line of its respective triangle for common or hip bars and determine the true lengths of the desired bars, from the hypothenuse.

Example: As no ventilator is shown in Fig. 186, there will be nothing to deduct for it, and the operation is as follows: 4 feet (short-

est side of frame) ÷ 2 = 2 feet. We have now the length with which to proceed to the triangle for common and hip bars. Thus the length of the common bar *c d* will be equal to twice the amount of A O in Fig. 184, while the length of the hip bar *b e* in Fig. 186, will be equal to twice the amount of B O in Fig. 185. Referring to Figs. 186 and 187 the jack bars *i j* are spaced 16 inches, therefore, the length of the jack bar for 12 inches will equal A O in Fig. 184, and 4 inches equal to 4° O; both of which are added together for the full length.

The lengths of the common and hip bars will be shorter in Fig. 187 because a ventilator has been used, while in Fig. 186 a ridge bar was employed. To obtain the lengths of the common and hip bars in Fig. 187 use Rule 3: 48 inches (length of short side) − 4 inches (width of inside ventilator) = 44 inches; and 44 inches ÷ 2 = 22 inches or 1 foot 10 inches. Then the length of the common bar *c' d'* measured with a rule will be equal to A O in Fig. 184 and 10° O added together, and the length of the hip bar *e' f'* in Fig. 187 will be equal to B O in Fig. 185 and 10^x O added together. Use the same method where fractional parts of an inch occur. In laying out the patterns according to these measurements use the cuts shown in Figs. 178, 179, 180, and 181, being careful to measure from the arrowpoints shown on each pattern.

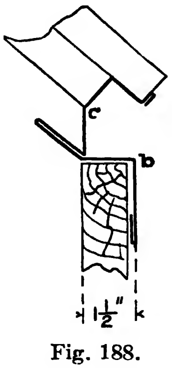


Fig. 188.

It will be noticed in Fig. 178 we always measure on line 4 in the patterns for the hip, common, and jack bars. This is done because the line 4 in the profiles E and E⁴ come directly on the slant line of the triangles which were traced to Figs. 184 and 185 and from which the true lengths were obtained. Where a curb might be used, as shown in Fig. 188, which would bring the bottom line of the bar $1\frac{1}{2}$ inches toward the inside of the frame *b*, all around, then instead of using the size of 4 x 8 feet as the basis of measurements deduct 3 inches on each side, making the basis of measurements 3 ft. 9 inches x 7 ft. 9 inches, and proceed as explained above.

ROOFING

A good metal covering on a roof is as important as a good foundation. There are various materials used for this purpose such as terne plate or what is commonly called roofing tin. The rigid body, or the base of roofing tin, consists of thin sheets of steel (black plates) that are coated with an alloy of tin and lead. Where a first-class job is desired soft and cold rolled copper should be used. The soft copper is generally used for cap flashing and allows itself to be dressed down well after the base flashing is in position. The cold-rolled or hard copper is used for the roof coverings. In some cases galvanized sheet iron or steel is employed. No matter whether tin, galvanized iron, or copper is employed the method of construction is the same, and will be explained as we proceed.

Another form of roofing is known as corrugated iron roofing, which consists of black or galvanized sheets, corrugated so as to secure strength and stiffness. Roofs having less than one-third pitch should be covered by what is known as flat-seam roofing, and should be covered (when tin or copper is used) with sheets 10 x 14 inches in size rather than with sheets 14 x 20 inches, because the larger number of seams stiffens the surface and prevents the rattling of the tin in stormy weather. Steep roofs should be covered by what is known as standing-seam roofing made from 14″ x 20″ tin or from 20″ x 28″. Before any metal is placed on a roof the roofer should see that the sheathing boards are well seasoned, dry and free from knots and nailed close together. Before laying the tin plate a good building paper, free from acid, should be laid on the sheathing, or the tin plate should be painted on the underside before laying. Corrugated iron is used for roofs and sides of buildings. It is usually laid directly upon the purlins in roofs, and held in place by means of clips of hoop iron, which encircle the purlins and are riveted to the corrugated iron about 12 inches apart. The method of constructing flat and double-seam roofing, also corrugated iron coverings, will be explained as we proceed.

TABLES

The following tables will prove useful in figuring the quantity of material required to cover a given number of square feet.

FLAT-SEAM ROOFING

Table showing quantity of 14 x 20-inch tin required to cover a given number of square feet with flat seam tin roofing. A sheet of 14 x 20 inches with with ½-inch edges measures, when edged or folded, 13 x 19 inches or 247 square inches. In the following all fractional parts of a sheet are counted a full sheet.

No. of sq. ft.	Sheets required	No. of sq. ft.	Sheets required	No. of sq. ft.	Sheets required	No. of sq. ft.	Sheets required
100	59	330	193	560	327	780	455
110	65	340	199	570	333	790	461
120	70	350	205	580	339	800	467
130	76	360	210	590	344	810	473
140	82	370	216	600	350	820	479
150	88	380	222	610	356	830	484
160	94	390	228	620	362	840	490
170	100	400	234	630	368	850	496
180	105	410	240	640	374	860	502
190	111	420	245	650	379	870	508
200	117	430	251	660	385	880	514
210	123	440	257	670	391	890	519
220	129	450	263	680	397	900	525
230	135	460	269	690	403	910	531
240	140	470	275	700	409	920	537
250	146	480	280	710	414	930	543
260	152	490	286	720	420	940	549
270	158	500	292	730	426	950	554
280	164	510	298	740	432	960	560
290	170	520	304	750	438	970	566
300	175	530	309	760	444	980	572
310	181	540	315	770	449	990	578
320	187	550	321				

1000 square feet, 583 sheets.

A box of 112 sheets 14 x 20 inches will cover approximately 192 square feet.

Example. How much 14 x 20 inch tin with ½-inch edges is required to cover a roof 20 feet x 84 feet? Take 20 × 84 = 1,680 square feet.

Referring to the table for Flat Seam Roofing, 1000 square feet require 583 sheets and 680 square feet require 397 sheets, making a total of 980 sheets.

It should be understood that this amount is figured on the basis of 247 square inches in an edged sheet, which will be a trifle less when the sheets are laid on the roof.

Example. What quantity of 20 x 28-inch tin will be required to lay a standing seam roof, measuring 37 feet long x 45 feet in width? Take 37 × 45 = 1,665 square feet, or 16 squares and 65 feet. Referring to the table for Standing Seam Roofing, 16 squares require 4 boxes and 48 sheets, and 65 feet require 20 sheets, making a total of 4 boxes and 68 sheets.

STANDING-SEAM ROOFING

Table showing the quantity of 20 × 28-inch tin in boxes, and sheets required to lay any given standing-seam roof.

SQ. FEET	SHEETS	SQUARES	SQ. FEET	BOXES	SHEETS	SQUARES	BOXES	SHEETS
1	1	......	68	......	21	35	9	77
2	1	......	69	......	21	36	9	108
3	1	......	70	......	22	37	10	27
4	2	......	71	......	22	38	10	58
5	2	......	72	......	22	39	10	89
6	2	......	73	......	22	40	11	8
7	3	......	74	......	23	41	11	39
8	3	......	75	......	23	42	11	70
9	3	......	76	......	23	43	11	101
10	4	......	77	......	24	44	12	20
11	4	......	78	......	24	45	12	51
12	4	......	79	......	24	46	12	82
13	4	......	80	......	25	47	13	1
14	5	......	81	......	25	48	13	32
15	5	......	82	......	25	49	13	63
16	5	......	83	......	25	50	13	94
17	6	......	84	......	26	51	14	13
18	6	......	85	......	26	52	14	44
19	6	......	86	......	26	53	14	75
20	7	......	87	......	27	54	14	106
21	7	......	88	......	27	55	15	25
22	7	......	89	......	27	56	15	56
23	7	......	90	......	28	57	15	87
24	8	......	91	......	28	58	16	6
25	8	......	92	......	28	59	16	37
26	8	......	93	......	28	60	16	68
27	9	......	94	......	29	61	16	99
28	9	......	95	......	29	62	17	18
29	9	......	96	......	29	63	17	49
30	10	......	97	......	30	64	17	80
31	10	......	98	......	30	65	17	111
32	10	......	99	......	30	66	18	30
33	10	......	100	......	31	67	18	61
34	11	1	......	......	31	68	18	92
35	11	2	......	......	62	69	19	11
36	11	3	......	......	93	70	19	42
37	12	4	......	1	12	71	19	73
38	12	5	......	1	43	72	19	104
39	12	6	......	1	74	73	20	23
40	13	7	......	1	105	74	20	54
41	13	8	......	2	24	75	20	85
42	13	9	......	2	55	76	21	4
43	13	10	......	2	86	77	21	35
44	14	11	......	3	5	78	21	66
45	14	12	......	3	36	79	21	97
46	14	13	......	3	67	80	22	16
47	15	14	......	3	98	81	22	47
48	15	15	......	4	17	82	22	78
49	15	16	......	4	48	83	22	109
50	16	17	......	4	79	84	23	28
51	16	18	......	4	110	85	23	59
52	16	19	......	5	29	86	23	90
53	16	20	......	5	60	87	24	9
54	17	21	......	5	91	88	24	40
55	17	22	......	6	10	89	24	71
56	17	23	......	6	41	90	24	102
57	18	24	......	6	72	91	25	21
58	18	25	......	6	103	92	25	52
59	18	26	......	7	22	93	25	83
60	19	27	......	7	53	94	26	2
61	19	28	......	7	84	95	26	33
62	19	29	......	8	3	96	26	64
63	19	30	......	8	34	97	26	95
64	20	31	......	8	65	98	27	14
65	20	32	......	8	96	99	27	45
66	20	33	......	9	15	100	27	76
67	21	34	......	9	46			

Size of sheet before working, 20 × 28 inches. Exposed on roof 27×17¾ inches. Square inches per sheet exposed 479¼ inches. Sheets per box 112.

NET WEIGHT PER BOX TIN PLATES

Basis 14 × 20, 112

Trade term . . .		80-lb.	85-lb.	90-lb.	95-lb.	100-lb.	IC	IXL	IX	IXX	IXXX	IXXXX
Weight per box, lb.		80	85	90	95	100	107	128	135	155	175	195
Size of sheets	Sheets per box											
10 x 14	225	80	85	90	95	100	107	128	135	155	175	195
14 x 20	112	80	85	90	95	100	107	128	135	155	175	195
20 x 28	112	160	170	180	190	200	214	256	270	310	350	390
10 x 20	225	114	121	129	136	143	153	183	193	221	250	279
11 x 22	225	138	147	156	164	172	184	232	234	268	302	337
11½ x 23	225	151	161	170	179	189	202	242	255	293	331	368
12 x 12	225	83	87	93	98	103	110	132	139	159	180	201
12 x 24	112	83	87	93	98	103	110	132	139	159	180	201
13 x 13	225	97	103	109	115	121	129	154	163	187	211	235
13 x 26	112	97	103	109	115	121	129	154	163	187	211	235
14 x 14	225	112	119	126	133	140	150	179	189	217	245	273
14 x 28	112	112	119	126	133	140	160	179	189	217	243	273
15 x 15	225	129	137	145	153	161	172	206	217	249	281	313
16 x 16	225	146	155	165	174	183	196	234	247	283	320	357
17 x 17	225	165	175	186	196	206	221	264	279	320	361	403
18 x 18	112	93	98	104	110	116	124	148	156	179	202	226
19 x 19	112	103	110	116	122	129	138	165	174	200	226	251
20 x 20	112	114	121	129	136	143	153	183	193	221	250	279
21 x 21	112	126	134	142	150	158	169	202	213	244	276	307
22 x 22	112	138	147	156	164	172	184	221	234	268	302	337
23 x 23	112	151	161	170	179	189	202	242	255	298	331	368
24 x 24	112	164	175	185	195	204	220	263	278	319	360	401
26 x 26	112	193	205	217	229	241	258	309	326	374	422	471
16 x 20	112	91	97	103	109	114	122	146	154	177	200	223
14 x 31	112	124	132	140	147	155	166	198	209	240	271	302
11¼ x 22¾	112	73	78	82	87	91	98					
13¼ x 17¾	112	60	71	76	80	84	90					
13¼ x 19¼	112	73	77	82	87	91	97					
13½ x 19½	112	75	80	85	89	94	100					
13½ x 19¾	112	76	81	86	90	95	102					
14 x 18¾	124	83	88	93	98	103	110					
14 x 19¼	120	83	88	93	98	103	110					
14 x 21	112	84	89	95	100	105	112					
14 x 22	112	88	94	99	105	110	118					
14 x 22¼	112	89	95	100	106	111	119					
15½ x 23	112	102	108	115	121	127	136					

STANDARD WEIGHTS AND GAUGES OF TIN PLATES

Trade term	65-lb.	70-lb.	75-lb.	80-lb	85-lb.	90-lb.	95-lb.	100-lb.
Nearest wire gauge No.	35	35	34	33	32	31	31	30
Weight, square foot, lb.	.298	.322	.345	.367	.390	.413	.436	.459
Weight, box, 14 x 20, lb. . .	65	70	75	80	85	90	95	100

Trade term ...	IC	IXL	IX	IXX	IXXX	IXXXX	IXXXXX
Nearest wire gauge No.	30	28	28	27	26	25	24
Weight, square foot, lb ...	.491	.588	.619	.712	.803	895	.987
Weight, box, 14 x 20, lb. ...	107	128	135	155	175	195	215

	IC 14 x 20	IC 20 x 28	IX 14 x 20	IX 20 x 28
Black plates before coating weight per 112 sheets ...	lb 95 to 100	lb. 190 to 200	lb. 125 to 130	lb. 250 to 260
When coated the plates.... weigh per 112 sheets	115 to 120	230 to 240	145 to 150	290 to 300

OTHER FORMS OF METAL ROOFING

There is another form of roofing known as metal slates and shingles, pressed in various geometrical designs with water-tight lock attachments so that no solder is required in laying the roof. Fig. 189 shows the general shape of these metal shingles which are made from tin, galvanized iron, and copper, the dots *a a a a* representing the holes for nailing to the wood sheathing. In Fig. 190, A represents the side lock, showing the first operation in laying the metal slate or shingle on a roof, *a* representing the nail. B, in the same figure, shows the metal slate or shingle in position covering the nail *b*, the valley *c* of the bottom slate allowing the water, if any, to flow over the next lower slate as in A in Fig. 189.

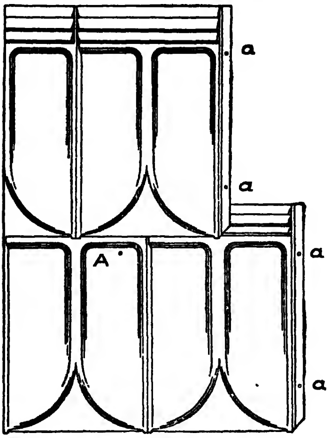


Fig. 189.

In Fig. 191 is shown the bottom slate A covered by the top slate B, the ridges *a a a* keeping the water from backing up. Fig. 192 shows the style of roof on which these shingles are employed, that is, on steep roofs. Note the construction of the ridge roll, A and B in Fig. 192, which is first nailed in position at *a a* etc., after which the shingles B are slipped under the lock *c*. Fig. 193 shows a roll hip covering which is laid from the top downward, the lower end of the hip having a projection piece for nailing at *a*, over which the top end of the next piece is inserted, thus

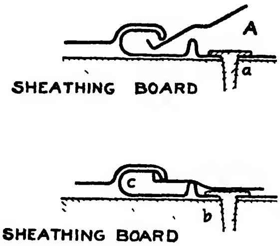


Fig. 190.

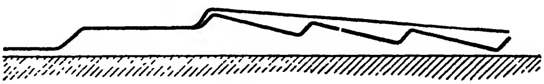


Fig. 191.

covering and concealing the nails. Fig. 194 represents a perspective view of a valley with metal slates, showing how the slates A are locked to the fold in the valley B. There are many other forms of

metal shingles, but the shapes shown herewith are known as the Cortright patents.

TOOLS REQUIRED

Fig. 195 shows the various hand tools required by the metal roofer; starting at the left we have the soldering copper, mallet, scraper,

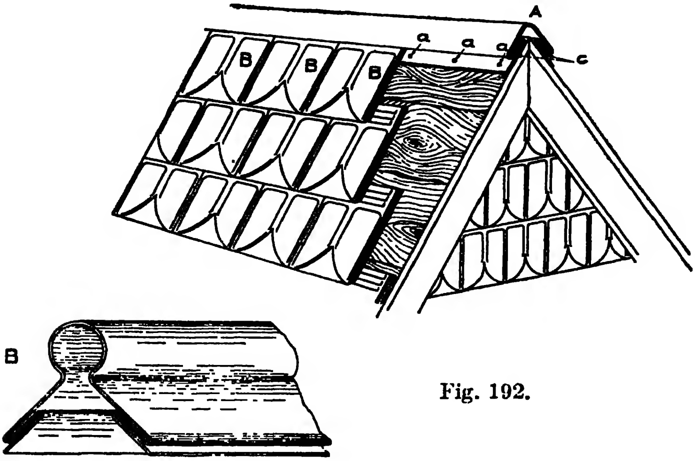


Fig. 192.

stretch-awl, shears, hammer, and dividers. In addition to these hand tools a notching machine is required for cutting off the corners of the

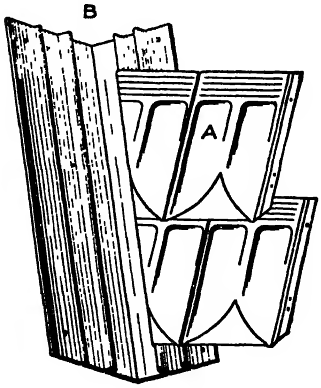


Fig. 194.

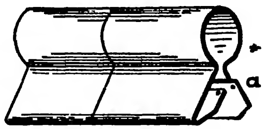


Fig. 193.

sheets, and roofing folders are required for edging the sheets in flat-seam roofing, and hand double seamer and roofing tongs for standing-seam roofing. The roofing double seamer and squeezing tongs can be used for standing-seam roofing (in place of the hand double seamer), which allow the operator to stand in an upright position if the roof is not too steep.

ROOF MENSURATION

While some mechanics understand thoroughly the methods of

laying the various kinds of roofing, there are some, however, who do not understand how to figure from architects' or scale drawings the amount of material required to cover a given surface in a flat, irregular shaped, or hipped roof. The modern house with its gables and va-

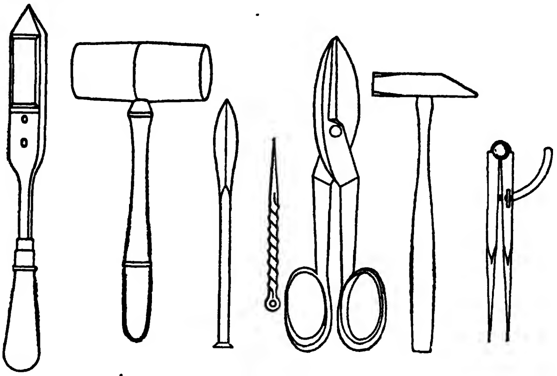


Fig. 195.

rious intersecting roofs, forming hips and valleys, render it necessary to give a short chapter on roof measurement. In Figs. 196 to 198 inclusive are shown respectively the plans with full size measurements for a flat, irregular, and intersected hipped roof, showing how the length of the hips and valleys are obtained direct from the architects'-scale drawings.

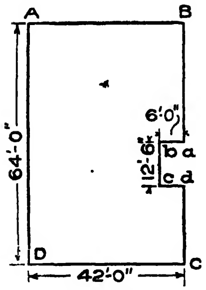


Fig. 196.

The illustrations shown herewith are not drawn to a scale as architects' drawings will be, but the measurements on the diagrams are assumed, which will clearly show the principles which must be applied when figuring from scale drawings. Assuming that the plans from which we are figuring are drawn to a quarter-inch scale, then when measurements are taken, every quarter inch represents one foot. $\frac{1}{8}$ inch = 6 inches, $\frac{1}{16}$ inch = 3 inches, etc. If the drawings were drawn to a half-inch scale, then $\frac{1}{2}$ inch = 12 inches, $\frac{1}{4}$ inch = 6 inches, $\frac{1}{8}$ inch = 3 inches, $\frac{1}{16}$ inch = $1\frac{1}{2}$ inches, etc.

A B C D in Fig. 196 represents a flat roof with a shaft at one side as shown by *a b c d*. In a roof of this kind we will figure it as if there was no air shaft at all. Thus 64 feet × 42 feet = 2,688 square feet. The shaft is 12.5 × 6 feet = 75 square feet; then 2,688 feet − 75 feet =

2,613 square feet of roofing, to which must be added an allowance for the flashing turning up against and into the walls at the sides.

In Fig. 197 is shown a flat roof with a shaft at each side, one shaft being irregular, forming an irregular shaped roof. The rule for obtaining the area is similar to that used for Fig. 196 with the exception that the area of the irregular shaft *x x x x* in Fig. 197 is determined differently to that of the shaft *b c d e*. Thus A B C D = 108 feet × 45 feet = 4,860 square feet. Find the area of *b c d e* which is 9.25 × 39.5 = 365.375 or 365⅜ square feet. To find the area of the irregular shaft, bisect *xx* and *xx* and obtain *a a*, measure the length of *a a* which is 48 feet, and multiply by 9. Thus 48 × 9 = 412, and 412 + 365.375 = 777.375. The entire roof minus the shafts = 4,860 square feet − 777.375 = 4,082.625 square feet of surface in Fig. 197.

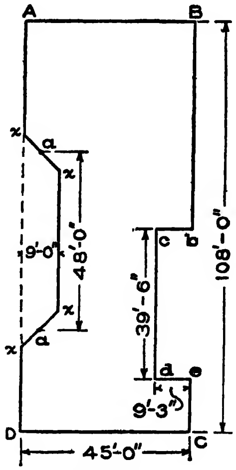


Fig. 197.

In Fig. 198 is shown the plan, front, and side elevations of an intersected hipped roof. A B C D represents the plan of the main build-

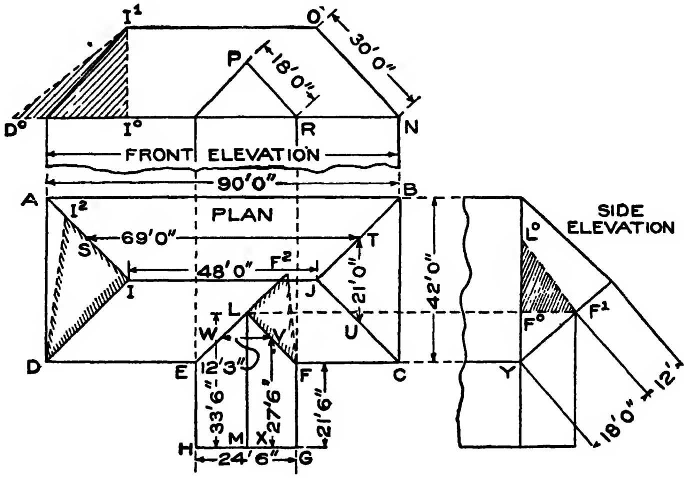


Fig. 198.

ing intersected by the wing E F G H. We will first figure the main roof as if there were no wing attached and then deduct the space taken

up by the intersection of the wing. While it may appear difficult to some to figure the quantities in a hipped roof, it is very simple, if the rule is understood. As the pitch of the roof is equal on four sides the length of the rafter shown from O to N in front elevation represents the true length of the pitch on each side. The length of the building at the eave is 90 feet and the length of the ridge 48 feet. Take $90 - 48 = 42$, and $42 \div 2 = 21$. Now either add 21 to the length of the edge or deduct 21 from the length of the eave, which gives 69 feet as shown from S to T. The length of the eave at the end is 42 feet and it runs to an apex at J. Then take 42 feet $\div 2 = 21$, as shown from T to U. If desired the hip lines A I, J B and J C can be bisected, obtaining respectively the points S, T, and U, which when measured will be of similar sizes; 69 feet and 21 feet. As the length of the rafter O N is 30 feet, then multiply as follows: $69 \times 30 = 2070$. $21 \times 30 = 630$. Then $630 + 2{,}070 = 2{,}700$, and multiplying by 2 (for opposite sides) gives 5,400 square feet or 54 squares of roofing for the main building. From this amount deduct the intersection E L F in the plan as follows:

The width of the wing is 24 feet 6 inches and it intersects the main roof as shown at E L F. Bisect E L and L F and obtain points W and V, which when measured will be 12 feet 3 inches or one half of HG, 24 feet 6 inches. The wing intersects the main roof from Y to F^1 in the side elevation, a distance of 18 feet. Then take $18 \times 12.25 = 220.5$. Deduct 220.5 from $5400 = 5{,}179.5$. The wing measures 33 feet 6 inches at the ridge L M, and 21 feet 6 inches at the eave F G, thus making the distance from V to $X = 27$ feet 6 inches. The length of the rafter of the wing is shown in front elevation by P R, and is 18 feet. Then $18 \times 27.5 = 495$, and multiplying by 2 (for opposite side), gives 995 sq. ft. in the wing. We then have a roofing area of 5,179.5 square feet in the main roof and 995 square feet in the wing, making a total of 6,174.5 square feet in the plan shown in Fig. 198.

If it is desired to know the quantity of ridge, hips, and valleys in the roof, the following method is used. The ridge can be taken from the plans by adding $48' + 33'6'' = 81' - 6''$. For the true length of the hip I D in the plan, drop a vertical line from I^1 in the front elevation until it intersects the eave line 1°. On the eave line extended, place the distance I D in the plan as shown from 1° to D° and draw a line from D° to I^1 which will be the true length of the hip I D in the plan. Multiply this length by 4, which will give the amount of ridge capping re-

quired. This length of hip can also be obtained from the plan by taking the vertical height of the roof I° I′ in the elevation and placing it at right angles to I D in the plan, as shown, from I to I^2, and draw a line from I^2 to D which is the desired length.

For the length of the valley L F in the plan, drop a vertical line from F^1 in the side elevation until it intersects the eave line at F°. Take the distance F L in the plan and place it as shown from F° to L°, and draw a line from L° to F^1, which is the true length of the valley shown by L F in the plan. Multiply this length by 2, which will give the required number of feet of valley required. This length of valley can also be obtained from the plan by taking the vertical height of the roof of the wing, shown by F° F^1 in the side elevation, and placing it at right angles to F L in the plan, from L to F^2, and draw a line from F^2 to F which is the desired length similar to F^1 L° in the side elevation.

FLAT-SEAM ROOFING

The first step necessary in preparing the plates for flat seam roofing is to notch or cut off the four corners of the plate as shown in Fig. 199 which shows the plate as it is taken from the box, the shaded corners *a a a a* representing the corners which are notched on the notching machine or with the shears. Care must be taken when cutting off these corners not to cut off too little otherwise the sheets will not edge well, and not to cut off too much, otherwise a hole will show at the corners when the sheets are laid. To find the correct amount to be cut off proceed as follows:

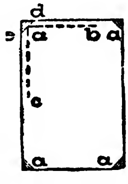


Fig. 199.

Assuming that a ½-inch edge is desired, set the dividers at ½ inch and scribe the lines *b a* and *a c* on the sheet shown in Fig. 199, and, where the lines intersect at *a*, draw the line *d e* at an angle of 45 degrees, which represents the true amount and true angle to be cut off on each corner. After all the sheets have been notched, they are edged as shown in Fig. 200, the long sides of the sheet being bent right and left, as shown at *a*, while the short side is bent as shown at *b*, making the notched corner appear as at *e*. In some cases after the sheets are edged the contract requires that the sheets be painted on the underside before laying. This is usually done with a small brush, being careful that the edges of the sheets

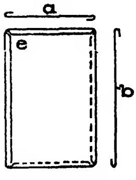


Fig. 200.

are not soiled with paint, which would interfere with soldering. Before laying the sheets the roof boards are sometimes covered with an oil or rosin-sized paper to prevent the moisture or fumes from below from rusting the tin on the underside. As before mentioned, the same method used for laying tin roofing would be applicable for laying copper roofing, with the exception that the copper sheets would have to be tinned about 1½ inches around the edges of the sheets after they are notched, and before they are edged.

In Fig. 201 is shown how a tin roof is started and the sheets laid when a gutter is used at the eaves with a fire wall at the side. A repre-

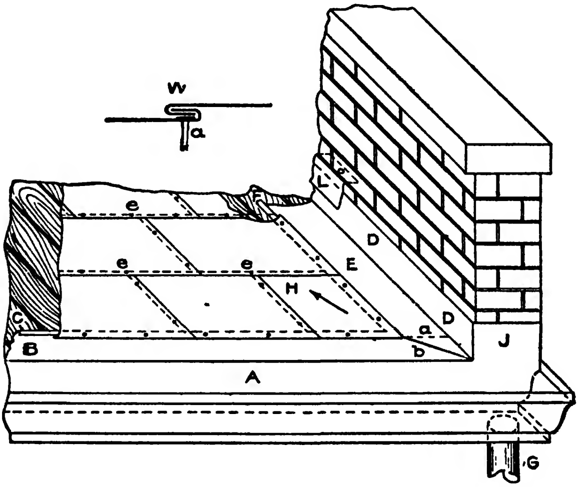


Fig. 201.

sents a galvanized iron gutter with a portion of it lapping on the roof, with a lock at C. In hanging the gutter it is flashed against the fire wall at J; after which the base flashing D D is put in position, flashing out on the roof at E, with a lock at F. Where the base flashing E miters with the flange of the gutter B it is joined as shown at *b*, allowing the flange E of the base flashing as shown by the dotted line *a*. As the water discharges at G, the sheets are laid in the direction of the arrow H, placing the nails at least 6 inches apart, always starting to nail at the butt *e e*, etc. Care should be taken when nailing that the nail heads are well covered by the edges, as shown in W, by *a*. Over the base flashing D D J the cap flashing L is placed, allowing it to go into the wall as at O.

When putting in base flashings there are two methods employed. In Fig. 202 is shown a side flashing between the roof and parapet wall. A shows the flashing turning out on the roof at B, with a lock C, attached and flashed into the wall four courses of brick above the roof line, as shown at D, where wall hooks and paintskins or roofer's cement are used to make a tight joint. Flashings of this kind should always be painted on the underside, and paper should be placed between the brick work and metal, because the moisture in the wall is apt to rust the tin. This method of putting in flashing is not advisable in new work, because when the building is new, the walls and beams are liable to settle and when this occurs the flange D tears out of the wall, and the result is disagreeable leaks that stain the walls. When a new roof is to be placed on an old building where the walls and copings are in place and the brick work and beams have settled, there is not so much danger of leakage.

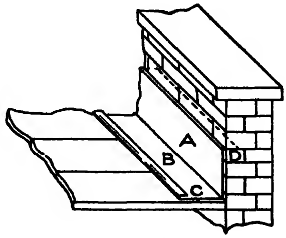


Fig. 202.

The proper method of putting in flashings and one which allows for the expansion and contraction of the metal and the settlement of the building is shown in Fig. 203, in which A shows the cap flashings,

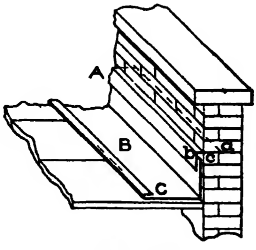


Fig. 203.

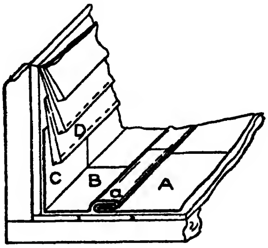


Fig. 204.

painted with two coats of paint before using. When the mason has built his wall up to four courses of brick above the roof line the cap flashing A is placed in position and the wall and coping finished; the base flashing B is then slipped under the cap A. In practice the cap flashing is cut 7 inches, then bent at right angles through the center, making each side *a* and *b* $3\frac{1}{2}$ inches. The base flashing B is then slipped under the cap flashing A as shown at C.

Where the cost is not considered and a good job is desired, it is better to use sheet lead cap flashings in place of tin. They last longer, do not rust, and can be dressed down well to lay tight onto the base flashings. Into the lock C the sheets are attached. After the sheets are laid the seams are flattened down well by means of a heavy mallet, with slightly convex faces, after which the roof is ready for soldering. When a base flashing is required on a roof which abuts against a wall composed of clap boards or shingles as shown in Fig. 204, then, after the last course of tin A has been laid, the flashing B with the lock *a* is locked into the course A and extends the required distance under the boards D. The flashing should always be painted and allowed to dry before it is placed in position. In the previous figures it was shown how the sheets are edged, both sides being edged right and left. In Fig. 205 is shown what is known as a valley sheet, where the short sides are edged both one way, as shown at *a a*, and the long sides right and left as shown at *b b*. Sheets of this kind are used when the water runs together from two directions as shown by A in Fig. 206. By having the locks *a* and *a* turned one way the roof is laid in both directions.

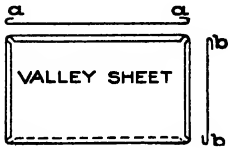


Fig. 205.

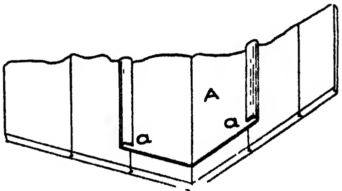


Fig. 206.

Fig. 207 shows a part plan of a roof and chimney A, around which the flashing B C D E is to be placed, and explains how the corners C and D are double seamed, whether on a chimney, bulkhead, or any other object on a roof when the water flows in the direction of the arrow F. The first operation is shown at *a* and the final operation at *b*. Thus it will be seen that the water flows past the seam and not against it. In laying flat seam roofing especially when copper is used, allowance must be made for the expansion and contraction of the sheets.

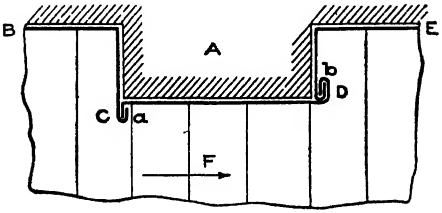
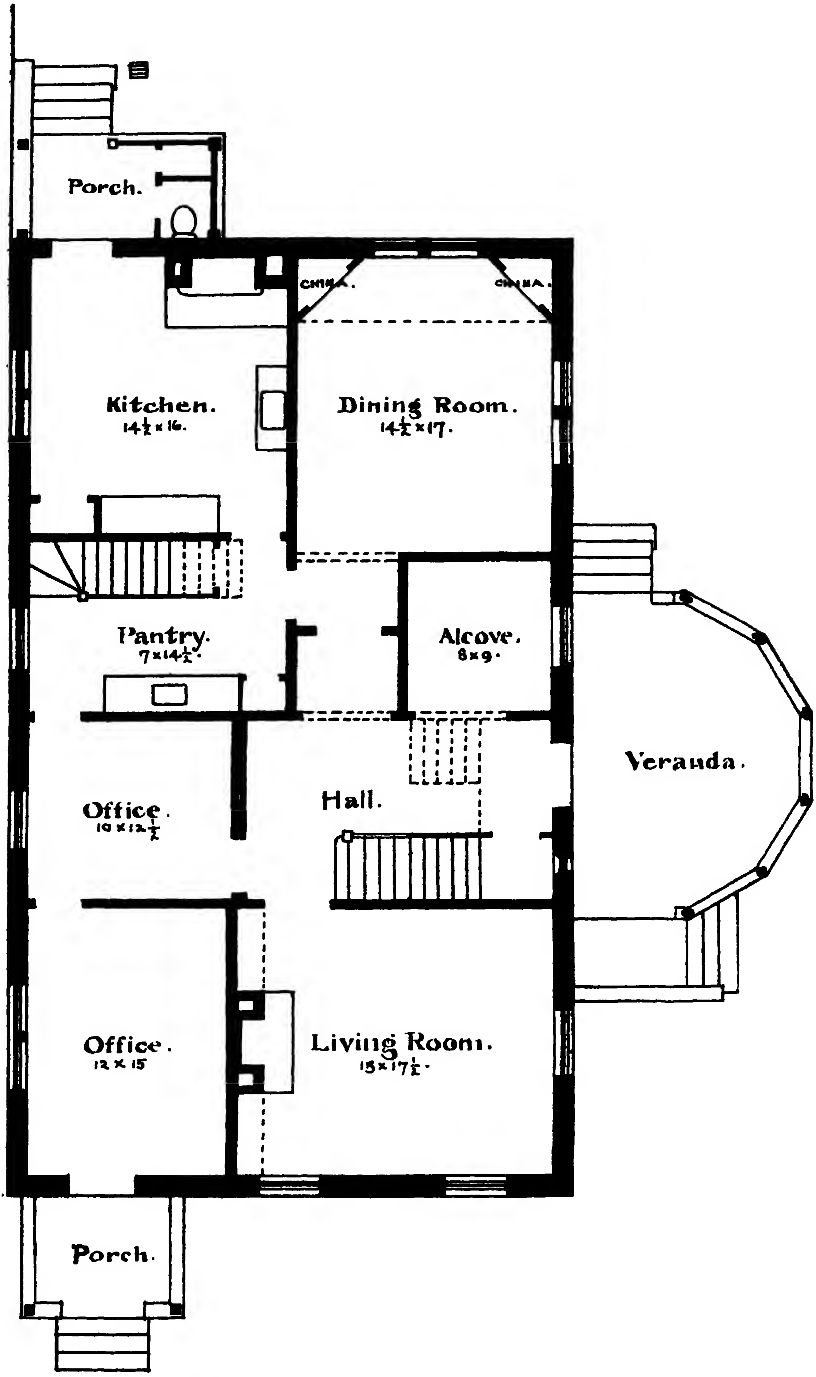


Fig. 207.

RESIDENCE OF DR. FOLTZ, CHESTNUT HILL, PHILADELPHIA, PA.

George T. Pearson, Architect, Philadelphia, Pa.

Planned to Meet the Requirements of a Physician's Residence and Office. The Exterior Treatment, as Indicated by the Timber Framings, Truncation of Roof, etc., is in the Dutch Style, the Base being Stone, Then a Band of Flemish-Bond, Dark Header Brickwork, and, above that, Rough Brick Walls Stuccoed. Plan Shown on Opposite Page.



PLAN OF RESIDENCE OF DR. FOLTZ, CHESTNUT HILL, PHILADELPHIA, PA.

George T. Pearson, Architect, Philadelphia, Pa.

Interior Woodwork is Treated in Dutch Style, of Dark Chestnut in Hall and Dining Room, and Painted Wood in Living Room and Second Story. Ceilings of First Story Have Beams Exposed, and Finished in Places with Quaint Carvings and Scroll Decoration Characteristic of the Dutch Style. Exterior View Shown on Opposite Page.

Care should be taken not to nail directly through the sheet as is shown in W, Fig. 201. While this method is generally employed in tin roofing, on a good job, as well as on copper roofing, cleats as shown at D in Fig. 208 should be used.

To show how they are used, A and B represent two locked-edged sheets. The lock on the cleat D is locked into the edge of the sheets and nailed into the roof boards at *a b c* and *d*, ar as often as required.

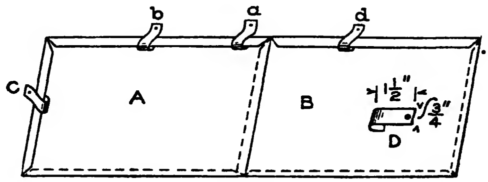


Fig. 208.

In this manner the entire roof can be fastened with cleats without having a nail driven into the sheets, thereby allowing for expansion and contraction of the metal. The closer these cleats are placed, the firmer the roof will be and the better the seams will hold. By using fewer cleats, time may be saved in laying the roof, but double this time is lost when soldering the seams, for the heat of the soldering copper

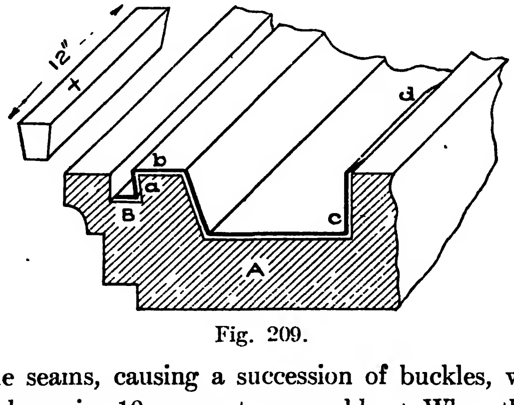


Fig. 209.

will raise the seams, causing a succession of buckles, which retard soldering and require 10 per cent more solder. When the seams are nailed or cleated close it lays flat and smooth and the soldering is done with ease and less solder.

When a connection is to be made between metal and stone or terra cotta, the method shown in Fig. 209 is employed. This illustration shows a stone or terra-cotta cornice A. The heavy line ***a b c d***

represents the gutter lining, which is usually made from 20-oz. cold-rolled copper. If the cornice A is of stone, the stone cutter cuts a raggle into the top of the cornice A as at B, dove-tail in shape, after which the lining *a b c d* is put in position as shown. Then, being careful that there is no water or moisture in the raggle B, molten lead is poured into the raggle and after it is cooled it is dressed down well with the caulking chisel and hammer.

By having the dove-tail cut, the lead is secured firmly in position, holding down the edge of the lining and making a tight joint. Should the cornice be of terra cotta this raggle is cut into the clay before it is baked in the ovens. This method of making connection between

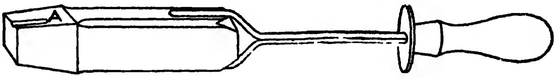


Fig. 210.

metal and stone is the same no matter whether a gutter or upright wall is to be flashed. When a flashing between a stone wall and roof is to be made tight, then instead of using molten lead, cakes of lead are cast in molds made for this purpose, about 12 inches long, and these are driven into the raggle B as shown in Fig. 209 at X.

The most important step in roofing is the soldering. The style of soldering copper employed is shown in Fig. 210 and weighs at least 8 pounds to the pair. When rosin is used as a flux, it is also employed in tinning the coppers, but when acid is used as a flux for soldering zinc or galvanized iron, salammoniac is used for tinning the coppers. It will be noticed that the soldering coppers are forged square at the ends, and have a groove filed in one side as shown at A. When the copper is turned upward the groove should be filed toward the lower side within $\frac{1}{4}$ inch from the corner, so that when the groove is placed upon the seam, as shown in Fig. 211, it acts as a guide to the copper as the latter is drawn along the seam. The groove *a* being in the position shown, the largest heated surface *b* rests directly on the seam, "soaking" it thoroughly with solder. As the heat draws the solder between the locks, about 6 pounds of $\frac{1}{2}$ and $\frac{1}{2}$ solder are required for 100 square feet of surface using 14 x 20-inch tin The use of acid in soldering seams in a tin roof is to be avoided as acid coming in contact with the

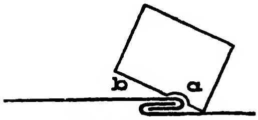


Fig. 211.

bare edges and corners, where the sheets are folded and seamed together, will cause rusting. No other soldering flux but good clean rosin should be employed. The same flux (rosin) should be used when soldering copper roofing whose edges have previously been tinned with rosin.

We will now consider the soldering of upright seams. The soldering copper to be employed for this purpose is shaped as shown in Fig. 212. It is forged to a wedge shape, about 1 inch wide and ¼ inch

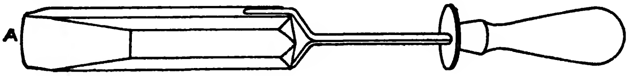


Fig. 212.

thick at the end, and is tinned on one side and the end only; if tinned otherwise, the solder, instead of remaining on the tinned side when soldering, would flow downward; by having the soldering copper tinned on one side only, the remaining sides are black and do not tend to draw the solder downward. The soldering copper being thus prepared, the upright seam, shown in Fig. 213, where the sheet B overlaps the sheet A 1″, is soldered by first tacking the seam to make it lay close, then thoroughly soaking the seam, and then placing ridges of solder across it to strengthen the same. In using the soldering copper it should be held in the position shown by C, which allows the solder to flow forward and into the seam, while if the copper were held as shown by D, the solder would flow backward and away from the seam. In "soaking" the seam with solder the copper should be placed directly over the lapped part, so that the metal gets thoroughly heated and draws the solder between the joint. It makes no difference where this cross joint occurs; the same methods are used.

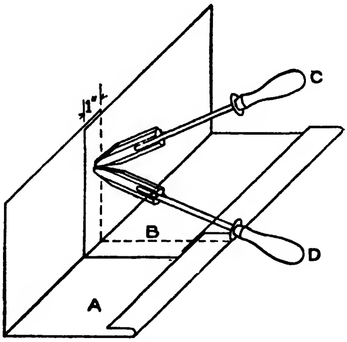


Fig. 213.

The roof being completed, the rosin is scraped off the seams and the roof cleaned and painted with good iron oxide and linseed oil paint. Some roofers omit the scraping of rosin and paint directly over it. This is the cause of rusting of seams which sometimes occurs. If the

paint is applied to the rosin, the latter, with time, will crack, and the rain will soak under the cracked rosin to the tin surface. Even when the surface of the roof is dry, by raising the cracked rosin, moisture will often be found underneath, which naturally tends to rust the plate more and more with each storm. If the rosin is removed, the entire tin surface is protected by paint.

One of the most difficult jobs in flat-seams roofing is that of covering a conical tower. As the roof in question is round in plan and tapering in elevation, it is necessary to know the method of cutting the various patterns for the sheets. In Fig. 214 A B C shows the elevation of a tower to be covered with flat seam roofing, using 10 × 14-inch tin at the base. Assuming that the tower through B C is 10 feet 6 inches, or 126 inches, in diameter, the circumference is obtained by multiplying 126 by 3.1416 which equals 395.8416, or say 396 inches. As 10 x 14-inch plate is to be used at the base of the tower the nearest width which can be employed, and which will divide the space into equal spaces, is $13\frac{1}{8}$ inches without edges, thus dividing the circumference in 30 equal spaces. This width of $13\frac{1}{8}$ inches together with the length of the rafter A B or B C in elevation, will be the basis from which all the patterns for the various courses will be laid off.

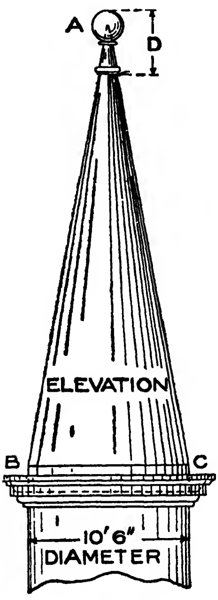


Fig. 214.

At any convenient place in the shop or at the building, stretch a piece of tar felting of the required length, tacking it at the four corners with nails to keep the paper from moving. Upon the center of the felting strike a chalk line as A B in Fig. 215, making it equal to the length of the rafter A B or A C in Fig. 214. At right angles to A B in Fig. 215 at either side, draw the lines B D and B C each equal to $6\frac{9}{16}$ inches, being one half of the $13\frac{1}{8}$ above referred to. From the points C and D draw lines to the apex A (shown broken). As the width of the sheet used is 10 inches and as we assume an edge of $\frac{3}{8}$ inch for each side, thus leaving $9\frac{1}{4}$ inches, measure on the vertical line A B lengths of $9\frac{1}{4}$ inches in succession, until the apex A is reached, leaving

the last sheet at the top to come as it may. Through the points thus obtained on A B draw lines parallel to C D intersecting the lines A C and A D as shown. Then the various shapes marked 1 2 3 etc. will be the net patterns for similarly numbered courses. Take the shears and cut out the patterns on the felting and number them as required.

For example, take the paper pattern No. 1, place it on a sheet of tin as shown in Fig. 216, and allow $\frac{3}{8}$-inch edges all around, and notch the corners A B C and D. Mark on the tin pattern "No. 1, 29 more", as 30 sheets are required to go around the tower, and cut 29 more for course No. 1. Treat all of the paper patterns from No. 1 to the apex in similar manner. Of course where the patterns become smaller in size at the top, the waste from other patterns can be used.

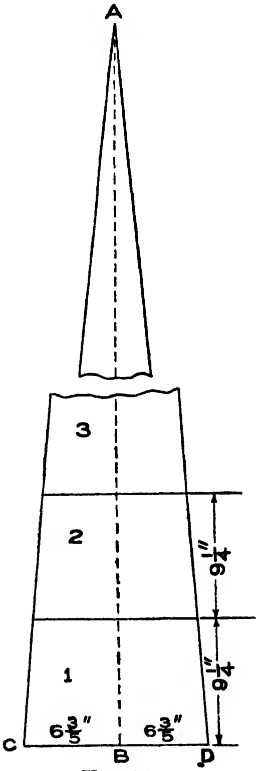


Fig. 215.

In Fig. 217 is shown how the sheets should be edged, always being careful to have the narrow side towards the top with the edge toward the outside, the same as in flat seam roofing. Lay the sheets in the usual manner, breaking joints as in general practice. As the seams are not soldered care must be taken to lock the edges well. After the entire roof is laid and before closing the seams with the mallet take a small brush and paint the locks with thick white lead, then close with the mallet. This will make a water-tight job. After the roof is completed the finial D in Fig. 214 is put in position.

Fig. 216.

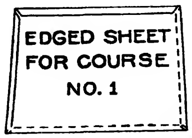


Fig. 217.

As the method used for obtaining the patterns for the various sheets in Fig. 215 is based upon the principle used in obtaining the envelope of a right cone, some student may say that in accurate pat-

terns the line from C to D and all following lines should be curved, as if struck with a radius from the center A, and not straight as shown. To those the writer would say that the curve would be so little on a small pattern, where the radius is so long, that a straight line answers the purpose just as well in all practical work; for it would amount to considerable labor to turn edges on the curved cut of the sheet, and there is certainly no necessity for it.

When different metals are to be connected together, as for instance tin roofing to copper flashing, or copper tubes to galvanized iron gutters, or zinc flashings in connection with copper linings, care must be taken to have the copper sheets thoroughly tinned on both sides where it joins to the galvanized iron, zinc, or other metal, to avoid any electrolysis between the two metals. It is a fact not well known to roofers that if we take a glass jar and fill it with water and place it in separately, two clean strips, one of zinc and the other of copper, and connect the two with a thin copper wire, an electrical action is the result, and if the connection remains for a long time (as the action is very faint) the zinc would be destroyed, because, it may be said, the zinc furnishes the fuel for the electrical action, the same as wood furnishes the fuel for the fire. Therefore, if the copper was not tinned, before locking into the other metal, and the joint became wet with rain, the coating of the metal would be destroyed by the electrical action between the two metals, and the iron would rust through.

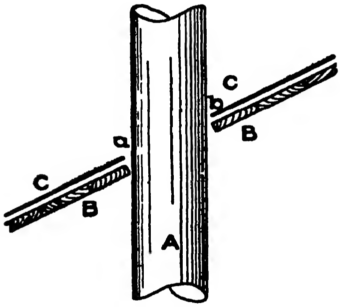


Fig. 218.

While the roofer is seldom called upon to lay out patterns for any roofing work occasion may arise that a roof flashing is required around a pipe passing through a roof of any pitch, as shown in Fig. 218, in which A represents a smoke or vent pipe passing through the roof B B, the metal roof flashing being indicated by C C. If the roof B B were level the opening to be cut into the flashing C C would simply be a true circle the same diameter as the pipe A. But where the roof pitches the opening in the flashing becomes an ellipse, whose minor axis is the same as the diameter of the pipe, and whose major axis is

equal to the pitch *a b*. In Fig. 219 is shown how this opening is obtained by the use of a few nails, a string, and a pencil, which the roofer will always have handy.

First draw the line A B representing the slant of the roof, and then make the pipe of the desired size passing through this line at its proper angle to the roof line. Next draw the center line R S of the pipe, as shown. Call the point where this line intersects the roof line, I, and the points where D E and C F intersect A B, G and H respectively. Through I draw K L at right angles to A B, making K I and I L each equal to the half diameter of the pipe. Having established the minor axis K L and the major axis G H, the ellipse is made by taking I H, or half the major axis, as a radius, and with L as a center strike arcs intersecting the major axis, at points M and N. Drive a small nail in each of these two points and attach a string to the nails as shown by the dotted lines K M N, in such a way that when a pencil point is placed in the string it will reach K. Move the pencil along the string, keeping it taut all the time until the ellipse K H L G is obtained. Note how the position of the string changes when it reaches *a*, then *b*, etc.

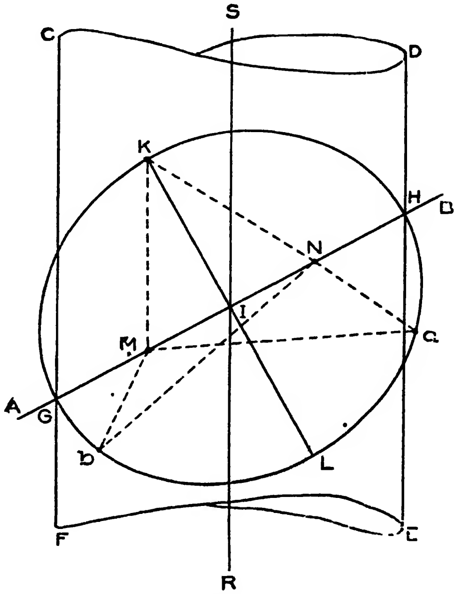


Fig. 219.

STANDING-SEAM ROOFING

Another form of metal roofing is that known as standing seam, which is used on steep roofs not less than $\frac{1}{6}$ pitch, or $\frac{1}{6}$ the width of the building. It consists of metal sheets whose cross or horizontal seams are locked as in flat seam roofing, and whose vertical seams are standing locked seams, as will be described in connection with Figs.

220 to 229 inclusive. Assume that 14 x 20-inch sheets are used and the sheets are edged on the 20-inch sides only, as shown by A in Fig. 220, making the sheet 13 x 20 inches. After the required number of sheets have been edged, and assuming that the length of the pitched roof is 30 feet, then as many sheets are locked together as will be required, and the seams are closed with the mallet and soldered. In practice these strips are prepared of the required length in the shop, painted on the underside, and when dry are rolled up and sent to the building. If desired they can be laid out at the building, which avoids the buckling caused by rolling and transportation from the shop to the job.

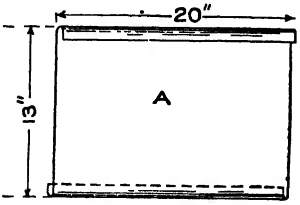


Fig. 220.

After the necessary strips have been prepared they are bent up with the roofing tongs, or, what is better and quicker, the roofing edger for standing-seam roofing. This is a machine into which the strips of tin are fed, being discharged in the required bent form shown at A or B in Fig. 221, bent up 1 inch on one side and 1¼ inches on the other side. Or the machine will, if desired, bend up 1¼ inches and 1½ inches, giving a ¾-inch finished doubled seam in the first case and a 1-inch seam in the second. When laying standing-seam roofing, in no case should any nails be driven into the sheets. This applies to tin, copper or galvanized iron sheets. A cleat should be used, as shown in Fig. 222, which also shows the full size for laying the sheets given in Fig. 221. Thus it will be seen in Fig. 222 that ¼ inch has been added over the measurements in Fig. 221, thus allowing edges.

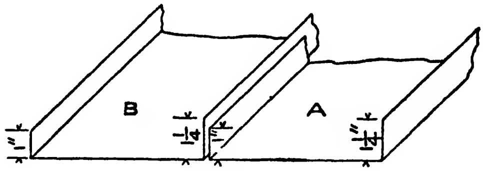


Fig. 221.

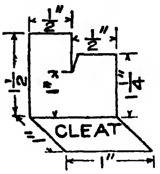


Fig. 222.

These cleats shown in Fig. 222 are made from scrap metal; they allow for the expansion and contraction of the roofing and are used in practice as shown in Fig. 223, which represents the first operation in laying a standing-seam roof, and in which A represents the gutter with a lock attached at B. The

gutter being fastened in position by means of cleats under the lock B—the same as in flat seam roofing—the standing seam strips are laid as follows: Take the strip C and lock it well into the lock B of the gutter A as shown, and place the cleat shown in Fig. 222 tightly against the upright bend of the strip C in Fig. 223 as shown at D, and fasten it to the roof by means of a 1-inch roofing nail *a*.

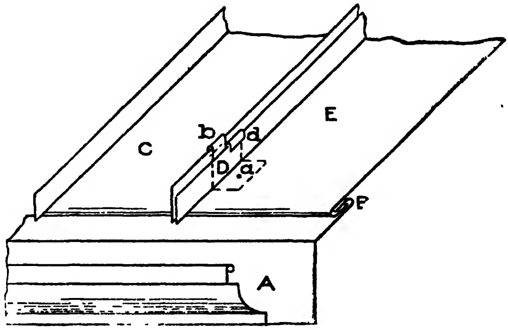


Fig. 223.

Press the strip C firmly onto the roof and turn over edge *b* of the cleat D. This holds the sheet C in position. Now take the next sheet E, press it down and against the cleat D and turn over the edge *d*, which holds E in position. These cleats should be placed about 18 inches

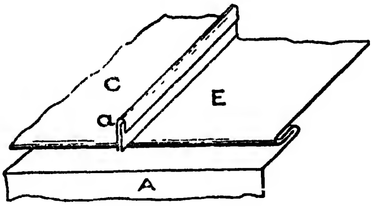


Fig. 224.

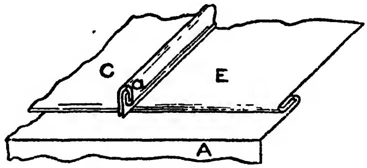


Fig. 225.

apart and by using them it will be seen that no nails have been driven through the sheets, the entire roof being held in position by means of the cleats only.

The second operation is shown in Fig. 224. By means of the hand double seamer and mallet or with the roofing double seamers and squeezing tongs, the single seam is made as shown at *a*. The third and last operation is shown in Fig. 225 where by the use of the same tools the doubled seam *a* is obtained. In Fig. 226 is shown how the finish is made with a comb ridge at the top. The sheets A A A have

on the one side the single edge as shown, while the opposite side B has a double edge turned over as shown at *a*. Then, standing seams *b b b* are soldered down to *e*.

In Fig. 227 is shown how the side of a wall is flashed and counter

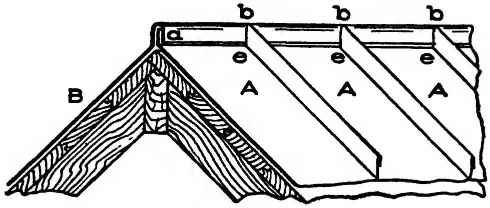


Fig. 226.

flashed. A shows the gutter, B the leader or rain water conductor, and C the lock on the gutter A, fastened to the roof boards by cleats

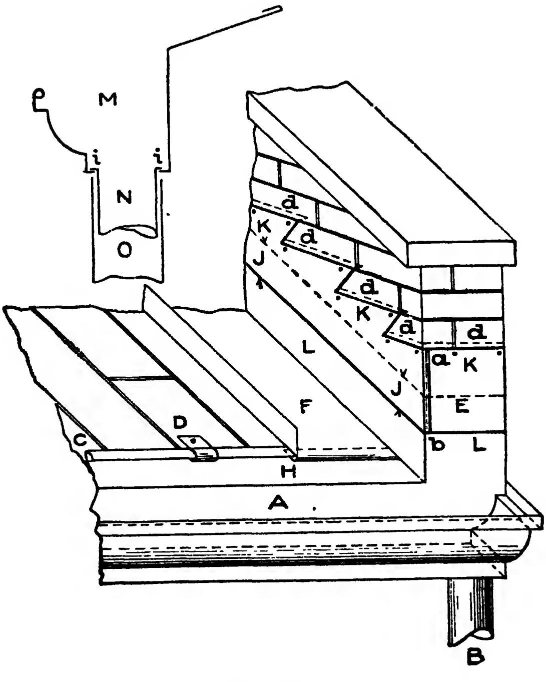


Fig. 227.

as shown at D. The back of the gutter is flashed up against the wall as high as shown by the dotted line E. F represents a standing-seam strip locked into the gutter at H and flashed up against the wall as high

as shown by the dotted line J J. As the flashing J J E is not fastened at any part to the wall the beams or wall can settle without disturbing the flashing. The counter or cap flashing K K K is now stepped as shown by the heavy lines, the joints of the brick work being cut out to allow a one-inch flange *d d d* etc. to enter. This is well fastened with flashing hooks, as indicated by the small dots, and then made water-tight with roofer's cement. As will be seen the cap flashing overlaps the base flashing a distance indicated by J J and covers to L L; the corner is double seamed at *a b*. M shows a sectional view through the gutter showing how the tubes and leaders are joined. The tube N is flanged out as shown at *i i*, and soldered to the gutter; the leader O is then slipped over the tube N as shown, and fastened.

In the section on Flat-Seam Roofing it was explained how a conical tower, Fig. 214, would be covered. It will be shown now how this tower would be covered with standing-seam roofing. As the circumference of the tower at the base is 396 inches, and assuming that 14 x 20-inch tin plate is to be used at the base of the tower, the nearest width which can be employed and which will divide the base into equal spaces is $17\frac{5}{23}$ inches, without edges, thus dividing the circumference into 23 equal parts. Then the width of $17\frac{5}{23}$ inches and the length of the rafter A B or A C in elevation will be the basis from which to construct the pattern for the standing seam strip, for which proceed as follows:

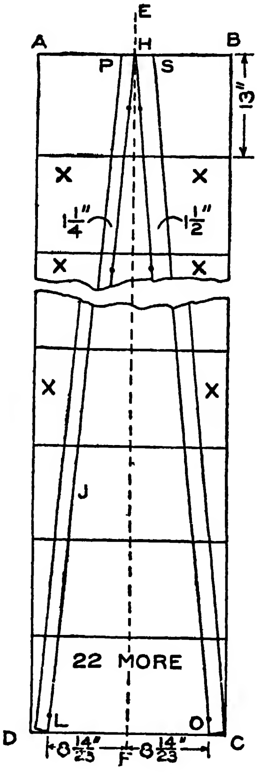


Fig. 228.

Let A B C D in Fig. 228 represent a 20-inch wide strip locked and soldered to the required length. Through the center of the strip draw the line E F. Now measure the length of the rafter A B or A C in Fig. 214 and place it on the line E F in Fig. 228 as shown from H to F. At right angles to H F on either side draw F O and F L making each equal to $8\frac{14}{23}$ inches, being one half of the $17\frac{5}{23}$ above referred to.

From points L and O draw lines to the apex H (shown broken). At right angles to H L and H O draw lines H P equal to 1¼ inches and H S equal to 1½ inches respectively. In similar manner draw L D and O C and connect by lines the points P D and S C. Then will P S C D be the pattern for the standing seam strip, of which 22 more will be required. When the strips are all cut out, use the roofing tongs and bend up the sides, after which they are laid on the tower, fastened with cleats, and double seamed with the hand seamer and mallet in the usual manner.

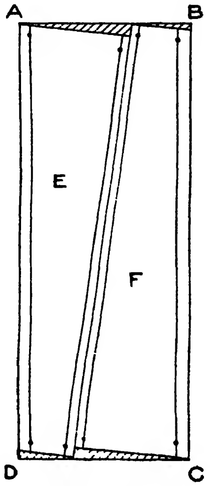


Fig. 229.

If the tower was done in copper or galvanized sheet iron or steel, where 8-foot sheets could be used, as many sheets would be cross-locked together as required; then metal could be saved, and waste avoided, by cutting the sheets as shown in Fig. 229 in which A B C D shows the sheets of metal locked together, and E and F the pattern sheets, the only waste being that shown by the shaded portion. Where the finial D in Fig. 214 sets over the tower, the standing seams are turned over flat as much as is required to receive the finial, or small notches would be cut into the base of the finial, to allow it to slip over the standing seams. Before closing the seams, they are painted with white lead with a tool brush, then closed up tight, which makes a good tight job.

CORRUGATED IRON ROOFING AND SIDING

Corrugated iron is used for roofs and sides of buildings. It is usually laid directly upon the purlins in roofs constructed as shown in Figs. 230 and 231, the former being constructed to receive sidings of corrugated iron, while in the latter figure the side walls of the building are brick. Special care must be taken that the projecting edges of the corrugated iron at the eaves and gable ends of the roof are well secured, otherwise the wind will loosen the sheets and fold them up. The corrugations are made of various sizes such as 5-inch, 2½-inch, 1¼-inch and ¾-inch, the measurements always being from A to B in Fig. 232, and the depth being shown by C. The smaller corrugations give a

more pleasing appearance, but the larger corrugations are stiffer and will span a greater distance, thereby permitting the purlins to be further apart.

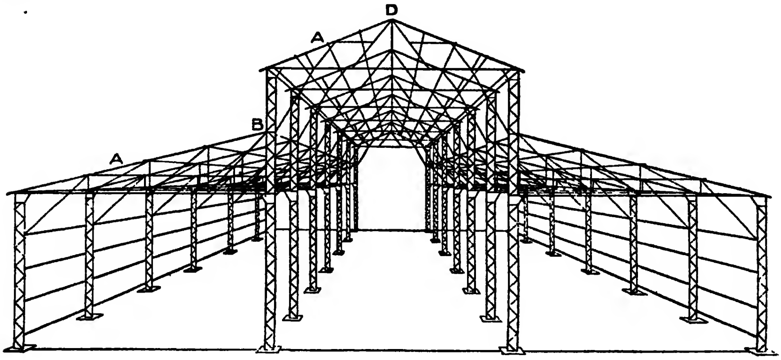


Fig. 230.

The thickness of the metal generally used for roofing and siding varies from No. 24 to No. 16 gauge. By actual trial made by The

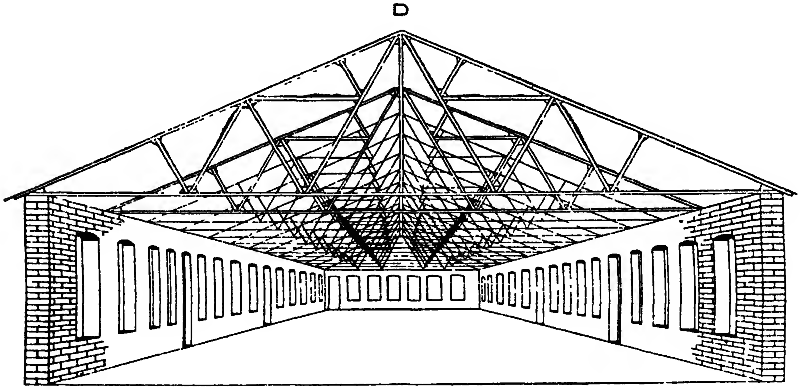


Fig. 231.

Keystone Bridge Company it was found that corrugated iron No. 20, spanning 6 feet, began to give permanent deflection at a load of 30 lb. per square foot, and that it collapsed with a load of 60 lb. per square foot. The distance between centers of purlins should, therefore, not exceed 6 feet, and preferably be less than this.

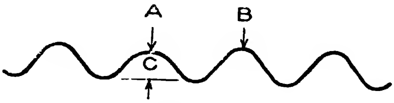


Fig. 232.

TABLES

The following tables will prove of value when desiring any information to which they appertain.

MEASUREMENTS OF CORRUGATED SHEETS

Dimensions of Sheets and Corrugations.

Kind of corrugation	Width of corrugation	Depth of corrugation	No. of corrugations to the sheet	Covering width after lapping one corrugation	Width of sheet after corrugated	Length of the longest sheets furnished
5 inch.	5 inch.	1 inch.	6	24 inch.	27 inch.	10 feet.
2½ inch.	2½ inch.	½ to ⅝ inch	10	24 inch.	26 inch.	10 feet.
1¼ inch.	1¼ inch.	⅜ to ½ inch.	19½	24 inch.	26 inch	10 feet
¾ inch.	¾ inch.	¼ inch.	34½	25 inch.	26 inch	8 feet.

RESULTS OF TEST

of a corrugated sheet No. 20, 2 feet wide, 6 feet long between supports, loaded uniformly with fire clay.

Load per square foot. lb.	Deflection at center under load. Inches.	Permanent Deflection, load removed.
5	½	0
10	¾	0
15	1	0
20	1¼	0
25	1½	0
30	1⅞	⅛
35	2¼	½
40	2⅝	¾
45	3½	1⅛
50	4	1½
55	6½	Not noted.
60	Broke down.	" "

The following table shows the distance apart the supports should be for different gauges of corrugated sheets:

Nos. 16 and 18 ....6 to 7 feet apart.
Nos. 20 and 22 ....4 to 5 feet apart.
No. 24 ....2 to 4 feet apart.
No. 28 .... 2 feet apart.

The following table is calculated for sheets 30½ inches wide before corrugating.

No. by Birmingham gauge	Thickness Inch	Weight per square ft., flat Lb	Weight per square ft., corrugated Lb.	Weight per square of 100 square feet, when laid, allowing 6 inches lap in length and 2½ inches or one corrugation in width of sheet, for sheet lengths of. 5 feet	6 feet	7 feet	8 feet	9 feet	10 feet	Weight per square ft., flat, galvanized Lb.
16	.065	2 61	3 28	365	358	353	350	348	346	2.95
18	.049	1 97	2.48	275	270	267	264	262	261	2.31
20	.035	1 40	1.76	198	192	190	188	186	185	1 74
22	.028	1 12	1.41	156	154	152	150	149	148	1.46
24	.022	.88	1.11	123	121	119	118	117	117	1.22
26	.018	.72	.91	101	99	97	97	96	95	1.06

LAYING CORRUGATED ROOFING

When laying corrugated iron on wood sheathing use galvanized iron nails and lead washers. The advantage in using lead washers is that they make a tight joint and prevent leaking and rusting at the nail hole; the washer being soft it easily shapes itself to any curve. In Fig. 233 is shown how these washers are used; A shows the full size nail

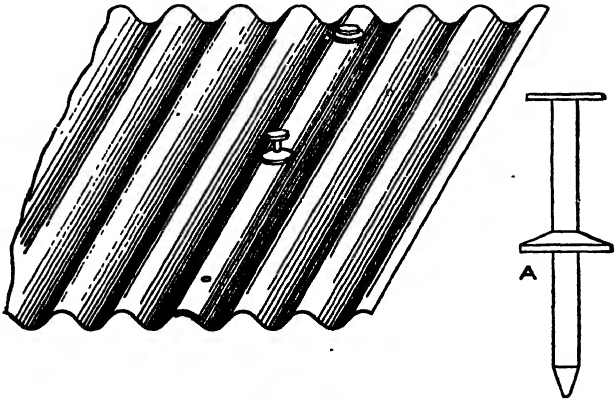


Fig. 233

and washer. When laying, commence at the left hand corner of the eave and end of the building. Continue laying to the ridge by lapping the second sheet over the first 4 inches, the left-hand edge being finished by means of a gable band A, formed as shown in Fig. 234, into which the corrugated sheet B is well bedded in roofer's cement C. When it is not desired to use this gable band the sheet must be well secured at the edge to keep the wind from raising the sheets from the roof in a storm, as at A in Fig. 230.

TABLES

The following tables will prove of value when desiring any information to which they appertain.

MEASUREMENTS OF CORRUGATED SHEETS

Dimensions of Sheets and Corrugations.

Kind of corrugation	Width of corrugation	Depth of corrugation	No. of corrugations to the sheet	Covering width after lapping one corrugation	Width of sheet after corrugated	Length of the longest sheets furnished
5 inch.	5 inch.	1 inch.	6	24 inch.	27 inch.	10 feet.
2½ inch.	2½ inch.	½ to ⅝ inch	10	24 inch.	26 inch	10 feet.
1¼ inch.	1¼ inch.	⅜ to ½ inch.	19½	24 inch.	26 inch	10 feet.
¾ inch.	¾ inch.	¼ inch.	34½	25 inch.	26 inch.	8 feet.

RESULTS OF TEST

of a corrugated sheet No. 20, 2 feet wide, 6 feet long between supports, loaded uniformly with fire clay.

Load per square foot. lb.	Deflection at center under load. Inches.	Permanent Deflection, load removed.
5	½	0
10	¾	0
15	1	0
20	1¼	0
25	1½	0
30	1⅞	⅛
35	2¼	½
40	2⅝	¾
45	3½	1⅛
50	4	1½
55	6½	Not noted.
60	Broke down.	" "

The following table shows the distance apart the supports should be for different gauges of corrugated sheets:

Nos. 16 and 18 .... 6 to 7 feet apart.
Nos. 20 and 22 .... 4 to 5 feet apart.
No. 24 .... 2 to 4 feet apart.
No. 28 .... 2 feet apart.

The following table is calculated for sheets 30½ inches wide before corrugating.

No. by Birmingham gauge	Thickness Inch	Weight per square ft., flat Lb.	Weight per square ft., corrugated Lb.	Weight per square of 100 square feet, when laid, allowing 6 inches lap in length and 2½ inches or one corrugation in width of sheet, for sheet lengths of. 5 feet	6 feet	7 feet	8 feet	9 feet	10 feet	Weight per square ft., flat, galvanized Lb.
16	.065	2 61	3 28	365	358	353	350	348	346	2.95
18	.049	1 97	2.48	275	270	267	264	262	261	2.81
20	.035	1 40	1.76	196	192	190	188	186	185	1 74
22	.028	1.12	1.41	156	154	152	150	149	148	1.46
24	.022	.88	1.11	123	121	119	118	117	117	1.22
26	.018	.72	.91	101	99	97	97	96	95	1.06

LAYING CORRUGATED ROOFING

When laying corrugated iron on wood sheathing use galvanized iron nails and lead washers. The advantage in using lead washers is that they make a tight joint and prevent leaking and rusting at the nail hole; the washer being soft it easily shapes itself to any curve. In Fig. 233 is shown how these washers are used; A shows the full size nail

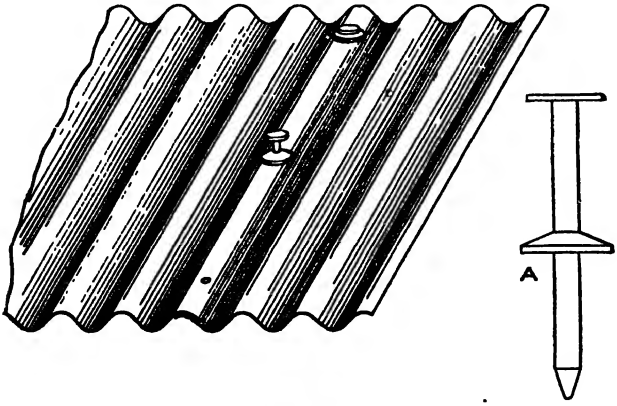


Fig. 233.

and washer. When laying, commence at the left hand corner of the eave and end of the building. Continue laying to the ridge by lapping the second sheet over the first 4 inches,the left-hand edge being finished by means of a gable band A, formed as shown in Fig. 234, into which the corrugated sheet B is well bedded in roofer's cement C. When it is not desired to use this gable band the sheet must be well secured at the edge to keep the wind from raising the sheets from the roof in a storm, as at A in Fig. 230.

Should the gable have a fire wall, then let the sheets A butt against the wall and flash with corrugated flashing as shown in Fig. 235, over which the regular cap or counter flashing is placed as explained in connection with Fig. 227. Should the ridge of the roof A butt against a wall, as shown at B in Fig. 230, then an end-wall flashing is used as is shown in Fig. 236 which must also be capped, by either using cap flashing or allowing the corrugated siding to overlap this end-wall flashing

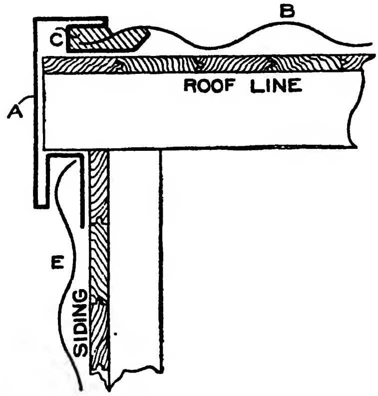


Fig. 234.

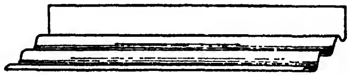


Fig. 235.

as would be the case at B in Fig. 230. Now commence the second course at the eaves, giving one and one half corrugations for side lap, being careful that the side corrugations center each other exactly and nail with washers as shown in Fig. 237. Nail at every other corrugation at end laps, and at about every 6 inches at side laps, nailing through top of corrugation as shown in Fig. 237. Continue laying in this manner until the roof is covered.

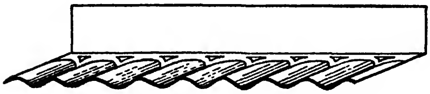


Fig. 236.

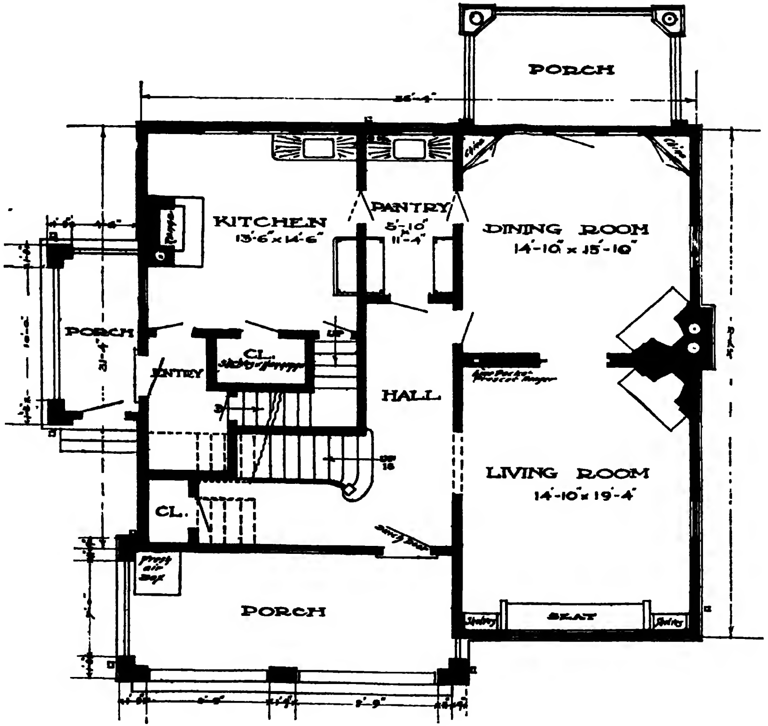
The same rule is to be observed in regard to laps and flashing if the corrugated iron were to be fastened to iron purlins, and the method of fastening to the iron frames would be accomplished as shown in Figs. 238 to 240 inclusive. Assuming that steel structures are to be covered, as shown in Figs. 230 and 231, then let A in Fig. 238 be the iron rafter, B the cross angles on which the sheets D are laid, then by means of the clip or clamp C, which is made from hoop iron and bent around the angle B, the sheets are riveted in position. In Fig. 239 is shown another form of clamp, which is bent over the bottom of the angle iron.

Fig. 237.

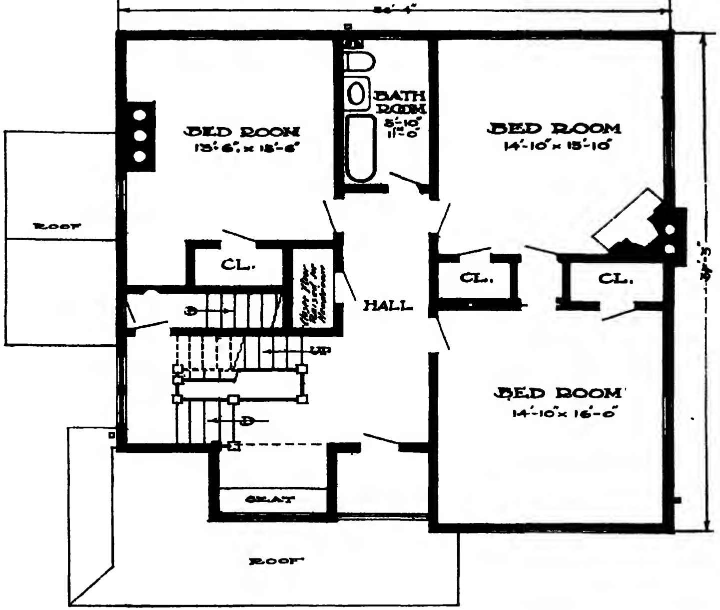
RESIDENCE OF C. D. DU BOIS, MONTCLAIR, NEW JERSEY

N. Le Brun & Sons, Architects, New York.

Walls of Stucco on Herringbone Expanded Steel Lath For Plans, See Opposite Page.



FIRST FLOOR PLAN



SECOND FLOOR PLAN

RESIDENCE OF C. D. DU BOIS, MONTCLAIR, NEW JERSEY

N. Le Brun & Sons, Architects, New York.

Fig. 240 shows still another method, where the clamp F is riveted to the sheet B at E, then turned around the angle A at D. To avoid having the storm drive in between the corrugated opening at the eaves, corrugated wood filler is used as shown in Fig. 241. This keeps out the

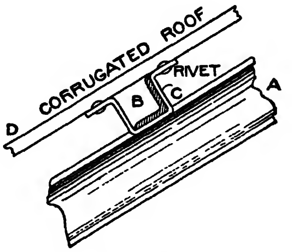


Fig. 238.

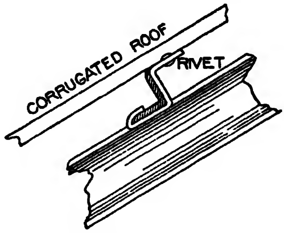


Fig. 239.

snow and sleet. On iron framing this is made of pressed metal. Another form of corrugated iron roofing is shown in Fig. 242. This is put down with cleats in a manner similar to standing-seam roofing.

If there are hips on the roof, the corrugated iron should be carefully cut and the hip covered with sheet lead. This is best done by having a wooden cove or filler placed on the hip, against which the roofing butts. Sheet lead is then formed over this wooden core and into the corrugations, and fastened by means of wood screws through the lead cap into the wooden core. The lead being soft, it can be worked into any desired shape. When a valley occurs in a hipped roof, form from plain sheet iron a valley as shown in Fig. 243, being sure to give it two coats of paint before laying, and make it from 24-inch wide sheets, bending up 12 inches on each side. Fit it in the valley, and cut the corrugated iron to fit the required angle. Then lap the corrugated iron over the valley from 6 to 8 inches.

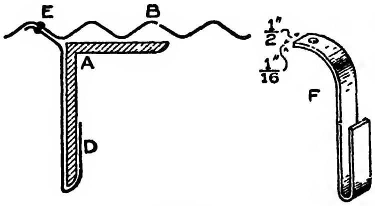


Fig 240.

Fig. 241.

When a chimney is to be flashed, as shown in Fig. 244, use plain iron, bending up and flashing into the chimney joints, and allowing

the flashing to turn up under the corrugated iron at the top about 12 inches and over the corrugated iron at the bottom about the same distance. At the side the flashing should have the shape of the corrugated iron and receive a lap of about 8 inches, the entire flashing

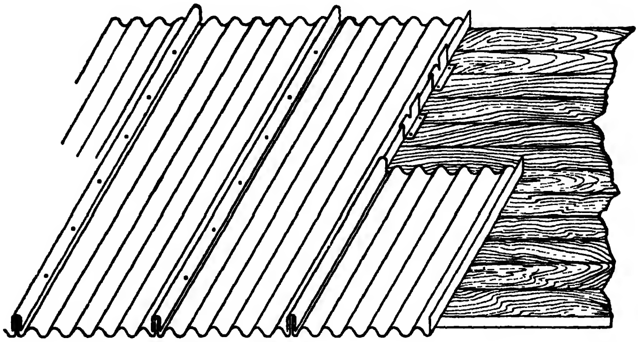


Fig. 242.

being well bedded in roofer's cement. When a water-tight joint is required around a smoke stack, as shown in Fig. 245, the corrugated iron is first cut out as shown, then a flashing built around one half the upper part of the stack to keep the water from entering inside. This is best done by using heavy sheet lead and riveting it to the sheets, using strips of similar corrugated iron as a washer to avoid damaging the lead. Before riveting, the flashing must be well bedded in roofer's cement and then make a beveled angle of cement to make a good joint. After this upright flashing is in position a collar is set over the same and fastened to the stack by means of an iron ring bolted and made tight as shown. Cement is used to make a water-tight joint around the stack. This construction gives room for the stack to sway and allows the heat to escape.

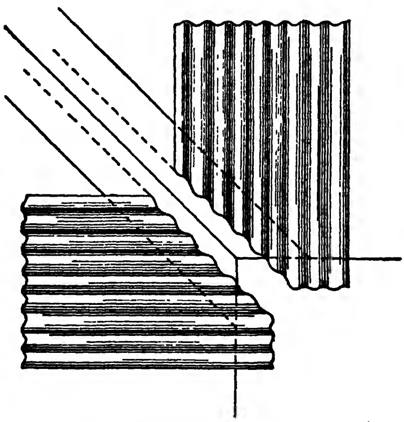


Fig. 243.

Sometimes the end-wall flashing shown in Fig. 236 can be used

to good advantage in building the upright flashing in Fig. 245. Where the corrugated iron meets at the ridge, as at D and D in Figs. 230 and

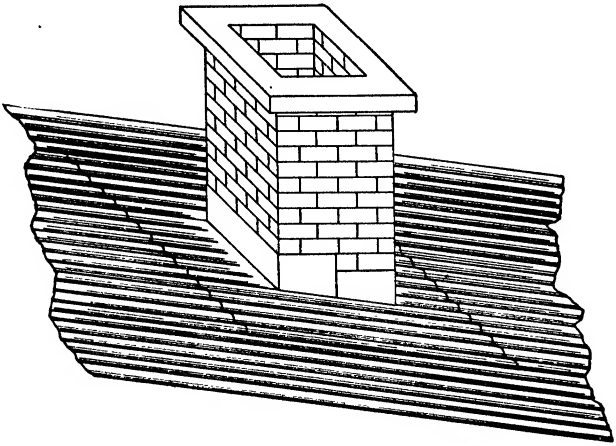


Fig. 244.

231, a wooden core is placed in position as explained in connection with the hip ridge, and an angle ridge, pressed by dealers who furnish the

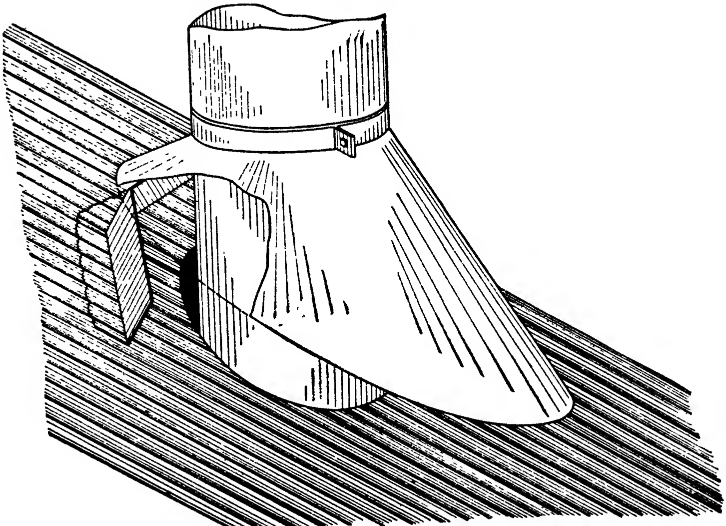


Fig. 245.

corrugated iron, is placed over the ridge as shown in Fig. 246. When a ridge roll is required, the shape shown in Fig. 247 is employed.

These ridges are fastened direct to the roof sheets by means of riveting or bolting.

LAYING CORRUGATED SIDING

Before putting on any corrugated siding or clapboarding, as shown in Fig. 248, a finish is usually made at the eaves by means of a

Fig. 246.

hanging gutter or a plain cornice, shown in Fig. 249, which is fastened to the projecting wooden or iron rafters. This method is generally used on elevators, mills, factories, barns, etc., where corrugated iron, crimped iron or clapboards are used for either roofing or siding. This

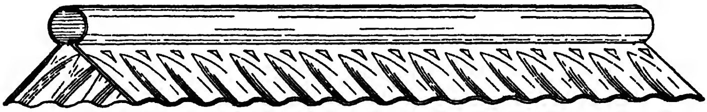


Fig. 247.

style of cornice covers the eaves and gable projections, so as to make the building entirely ironclad. When laying the siding commence at the left hand corner, laying the courses from base to cornice, giving the sheets a lap of two inches as the ends and one and one half corruga-

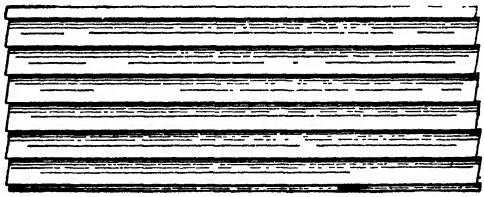


Fig. 248.

tions at the sides. Nail side laps every 6 inches and end laps at every other corrugation, driving the nails as shown in Fig. 250.

Where the sheets must be fastened to iron framing use the same method as explained in connection with Figs. 238, 239 and 240. In this case, instead of nailing the sheets, they would be riveted. If siding is put on the wooden studding care should be taken to space the studding the same distance apart as the laying width of the iron used. In

this case pieces of studding should be placed between the uprights at the end of each sheet to nail the laps. When covering grain elevators

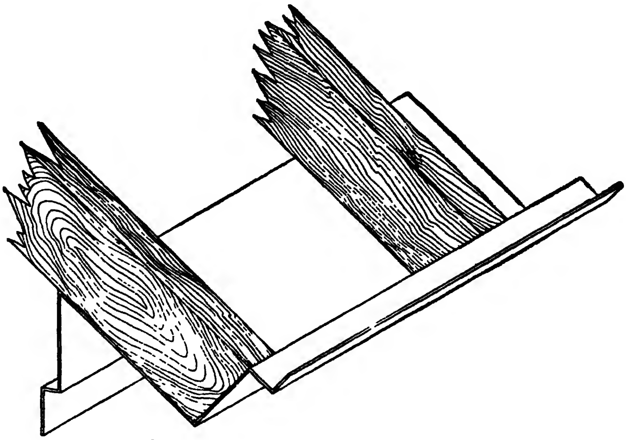


Fig. 249.

it is necessary to use swinging scaffolds. Commence at the base and carry up the course to the eave, the length of the scaffold. Commence at the left hand and give the sheets a lap of one corrugation on the side and a two-inch lap at the end. Nail or rivet in every corrugation 3 inches from the lower end of the sheet; this allows for settling of the building.

Fig. 250.

When any structure is to be covered on two or more sides, corner casings made of flat iron are employed, of a shape similar to that shown at B, Fig. 251. It will be seen that a rabbet is bent on both sides *a* and *b* to admit the siding. This makes a neat finish on the outside and hides the rough edges of the siding. If a window opening is to have casings a jamb is used as shown at A, Fig. 251, which has a similar rabbet at *a* to receive the siding, and a square bend at *b* to nail against the frame. In Fig. 252 is shown the cap of a window or opening. It is

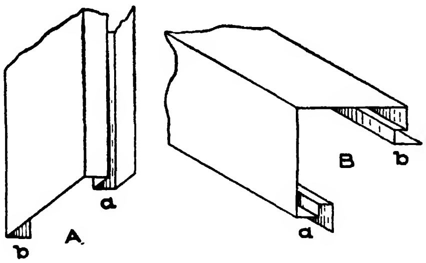


Fig. 251.

bent so that *a* is nailed to the window or other frame at the bottom, while *b* forms a flashing over which the siding will set. Fig. 253 shows the sill of a window, which has a rabbet at *a*, in which the siding is

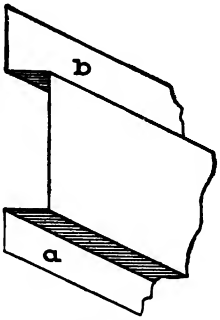


Fig. 252.

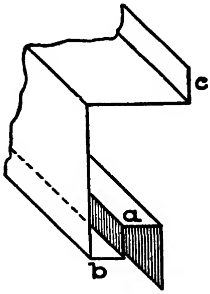


Fig. 253.

slipped; then *b* forms a drip, and any water coming over the sill passes over the siding without danger of leaks; *c* is nailed in white lead to the window frame.

Another use to which corrugated iron is put is to cover sheds and awnings. Sheets laid on wood are nailed in the usual manner, while sheets laid on angle iron construction are fastened as explained in the

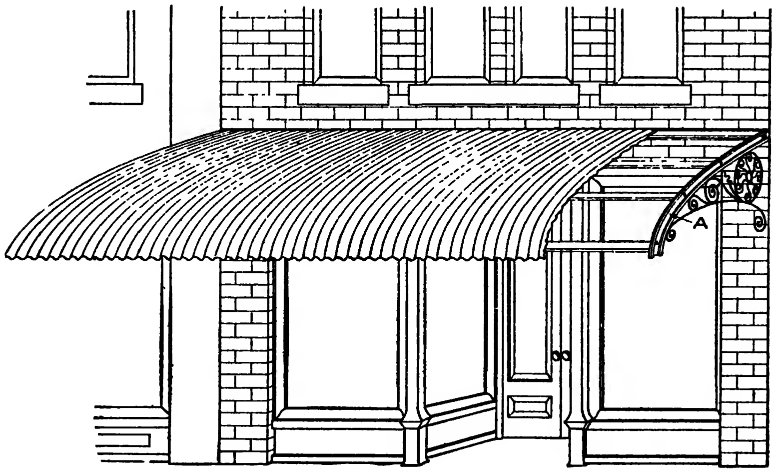
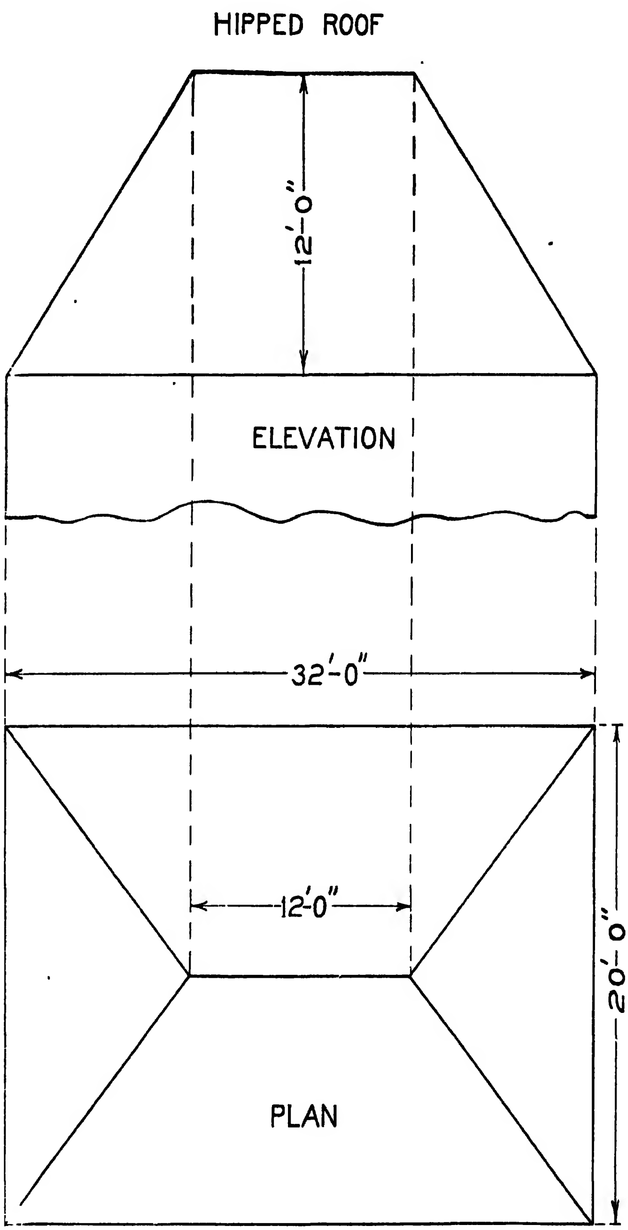


Fig. 254.

preceding sections. In Fig. 254 is shown an awning over a store laid on angle iron supports. In work of this kind, to make a neat appearance, the sheets are curved to conform to the iron bracket A.

PLATE IX



SCALE $\frac{1}{8}$" = ONE FOOT

EXAMINATION PLATES

SKYLIGHTS

The plates of this Instruction Paper should be laid out the same size as in the previous books (10 x 14 inches). The student should first practice on other paper, then copy and send the corrected drawing for correction and examination. These final Examination Plates to be drawn in this course will consist of Plates VI, VII, and VIII and will be that of a hipped skylight with a ventilator. No copies of the plates are given, but with the following explanation the student should be able to construct the same without any trouble. The pitch of the skylight is to be one third, and Fig. 178 is given as an example of the work to be done with the following exceptions. On plate VI, within ¼ inch inside of the margin lines, draw the one-half section of the skylight, the one-quarter plan, and the patterns for the common and jack bars. On Plate VII place a reproduction of the one-quarter plan omitting the plan of the jack bar; and from the plan of the hip construct the diagonal elevation of the hip bar, also its true profile and pattern. In this case the heights are taken from the one-half section in Plate VI and transferred to Plate VII so as to obtain the diagonal elevation. On Plate VIII place a tracing of the one-half section from Plate VI, and develop on Plate VIII the patterns for the curb as shown in Fig. 178. On Plate VIII also develop the patterns shown in Figs. 179, 180 and 181, so as to neatly fill the plate.

On plate IX is shown a plan and elevation of a hipped roof drawn to a scale of $\frac{1}{8}$ inch to the foot. The student is not to make any reproduction of this plate but is only to figure out the quantities in this roof also the amount of hip rolls required, following the rules given in connection with the problems on Roof Mensuration in this book.

CORNICE OVER BRICK BAY *

An elevation and plan of a brick bay are shown in the illustration, the sides of which are 8 inches, 3 feet 2 inches and 5 feet 10 inches wide. Laps or flanges for soldering are to be allowed on the 3 feet 2 inch pieces and no laps on the 8 inch and 5 feet 10 inch pieces. The lookouts or iron braces are indicated in the plan by the heavy dashes making a total of 9 required.

After the detail section is drawn and knowing the angle of the bay in plan, the angle is placed as shown by ABC, being careful to place CB on a line drawn vertically from 3–4 in the section. The miter line is then drawn as shown by BD, the section divided into equal spaces, and vertical lines dropped to the miter line BD as shown. At right angles to BC the girth of the section is drawn as shown by similar figures from 1 to 26, through which points at right angles to 1–26, lines are drawn and intersected by similar numbered lines drawn from the miter line BD at right angles to BC, thus obtaining the upper miter cut shown. Now using this miter cut in practice, make the distance from either points 25 or 24 (which represents the line of the wall) equal to 8 inches, 3 feet 2 inches and 5 feet 10 inches. The 3 feet 2 inches and 5 feet 10 inches have opposite miter cuts as shown.

As will be seen by the plan, two eight inch pieces will be required, one right and one left and two 3 feet 2 inch and one 5 feet 10 inch pieces. Nine iron lookouts will be required formed to the shape shown in the detail section, where holes are punched for bolting as there indicated.

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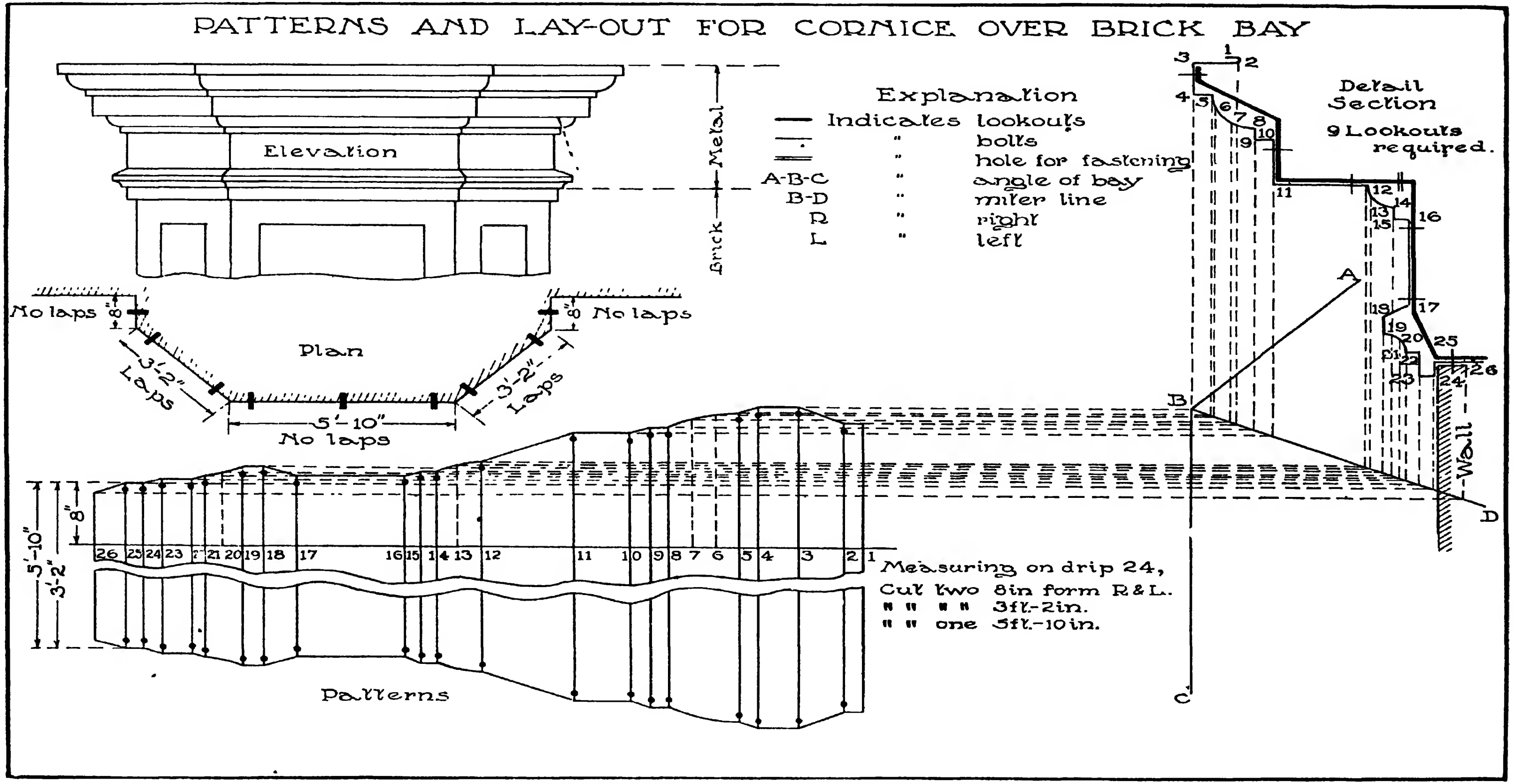
* The illustration referred to will be found on the back of this page.



FOR EXPLANATION OF THIS PROBLEM SEE BACK OF PAGE

SHEET METAL WORK

PART IV

CORNICE WORK

There is no trade in the building line to-day which has made such rapid progress as that of Sheet-Metal Cornice, or Architectural Sheet-Metal Work. It is not very long since the general scope of this branch of craftsmanship merely represented a tin-shop business on a large scale. But as things are to-day, this is changed. From an enlarged tin-shop business, sheet-metal cornice work, including under that title every branch of architectural sheet-metal work, has become one of the substantial industries of the country, comparing favorably with almost any other mechanical branch in the building trades. Nor is this work confined to the larger cities. In the smaller towns is shown the progress of architectural sheet-metal work in the erection of entire building fronts constructed from sheet metal.

CONSTRUCTION

Sheet-metal cornices have heretofore, in a great measure, been duplications of the designs commonly employed in wood, which, in turn, with minor modifications, were imitations of stone.

With the marked advancement of this industry, however, this need no longer be the case. A sheet-metal cornice is not now imitative. It possesses a variety and beauty peculiarly its own. No pattern is too complex or too difficult. Designs are satisfactorily executed in sheet metal which are impossible to produce in any other material. By the free and judicious application of pressed metal ornaments, a product is obtained that equals carved work. For boldness of figure, sharp and clean-cut lines, sheet-metal work takes the lead of all competitors.

In order that there may be no misunderstanding as to the various parts contained in what the sheet-metal worker calls a "cornice," Fig. 255 has been prepared, which gives the names of all the members in the "entablature"—the architectural name for what in the shop is

known as the cornice. The term "entablature" is seldom heard among mechanics, a very general use of the word "cornice" having supplanted it in the common language of business.

An entablature consists of three principal parts—the *cornice,* the *frieze,* and the *architrave.* A glance at the illustration will serve to show the relation that each bears to the others. Among mechanics the shop term for architrave is *foot-moulding*; for frieze, *panel*; and for

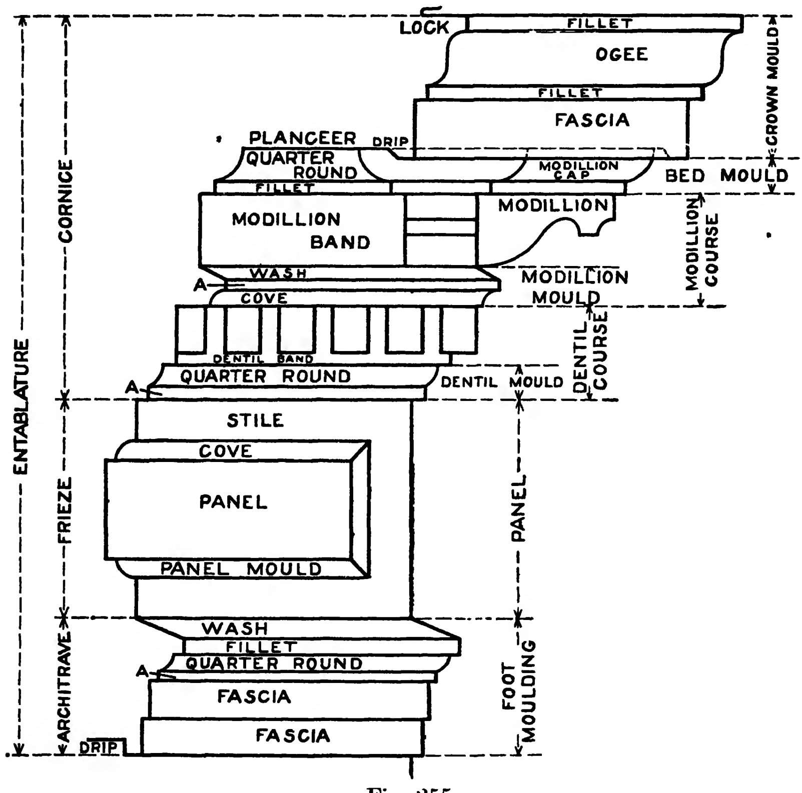


Fig. 255.

the subdivisions of the cornice, *dentil course, modillion course, bed-mould,* and *crown-mould.* In the modillion course, are the *modillion-band* and *modillion-mould*; while in the dentil course are the *dentil-band* and *dentil-mould. Drips* are shown at the bottom of the crown- and foot-mould fascias, and the ceiling under the crown mould is called the *planceer.* The edge at the top of the cornice is called a *lock*, and is used to lock the metal roofing into, when covering the top of the cor-

nice. In the panel, there are the *panel* proper, the *panel-mould,* and the *stile.* The side and front of the modillion are also shown.

Fig. 256 shows the side and front view of what is known as a bracket. Large terminal brackets in cornices, which project beyond the mouldings, and against which the mouldings end, are called trusses, a front and a side view of which are shown in Fig. 257. A block placed above a common bracket against which the moulding ends, is called a *stop block,* a front and a side view of which are shown in Fig. 258.

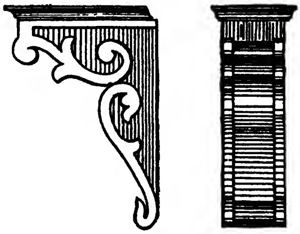


Fig. 256.

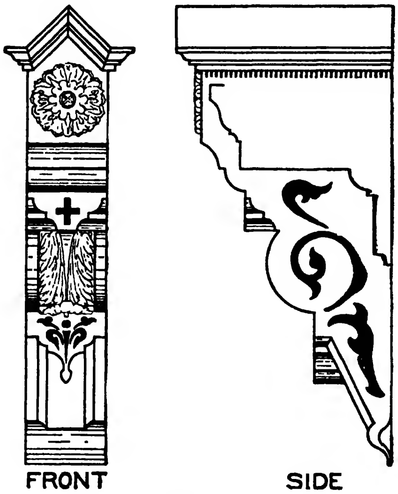


Fig. 257.

Fig. 259 is the front elevation of a cornice, in which are shown the truss, the bracket, the modillion, the dentil, and the panel. It is sometimes the case, in the construction of a cornice, that a bracket or modillion is called for, whose front and sides are carved as shown in the front and side views in Fig. 260. In that case, the brackets are obtained from dealers in pressed ornaments, who make a specialty of this kind of work. The same applies to capitals which would be required for pilasters or columns, such as those shown in Figs. 261 and 262. The pilaster or column would be formed up in sheet metal, and the capital purchased and soldered in position. In Fig. 263, A shows an inclined moulding, which, as far as general position is concerned, would be the same as a gable moulding.

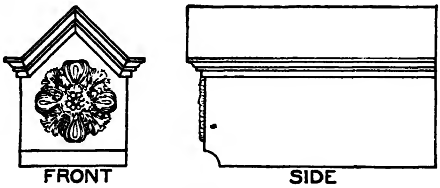
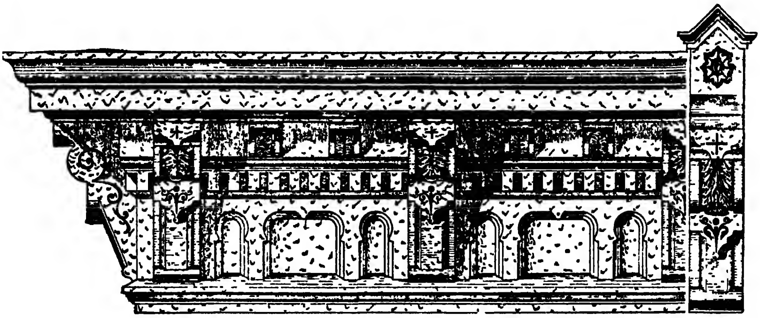


Fig. 258.

Raking mouldings are those which are inclined as in a gable or pediment; but, inasmuch as to miter an inclined moulding (as A) into a horizontal moulding (as B and C), under certain conditions, necessitates a change of profile, the term "to rake," among sheet-metal workers, has come to mean "to change profiles" for the accomplishment of



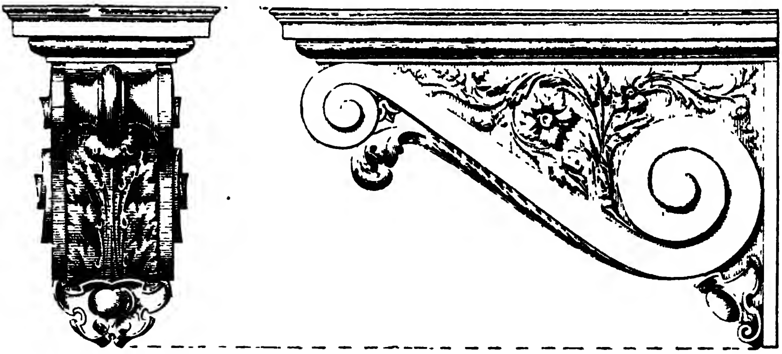
FRONT ELEVATION

Fig. 259

such a miter. Hence the term "raked moulding" means one whose profile has been changed to admit of mitering.

The term *miter*, in common usage, designates a joint in a moulding at any angle.

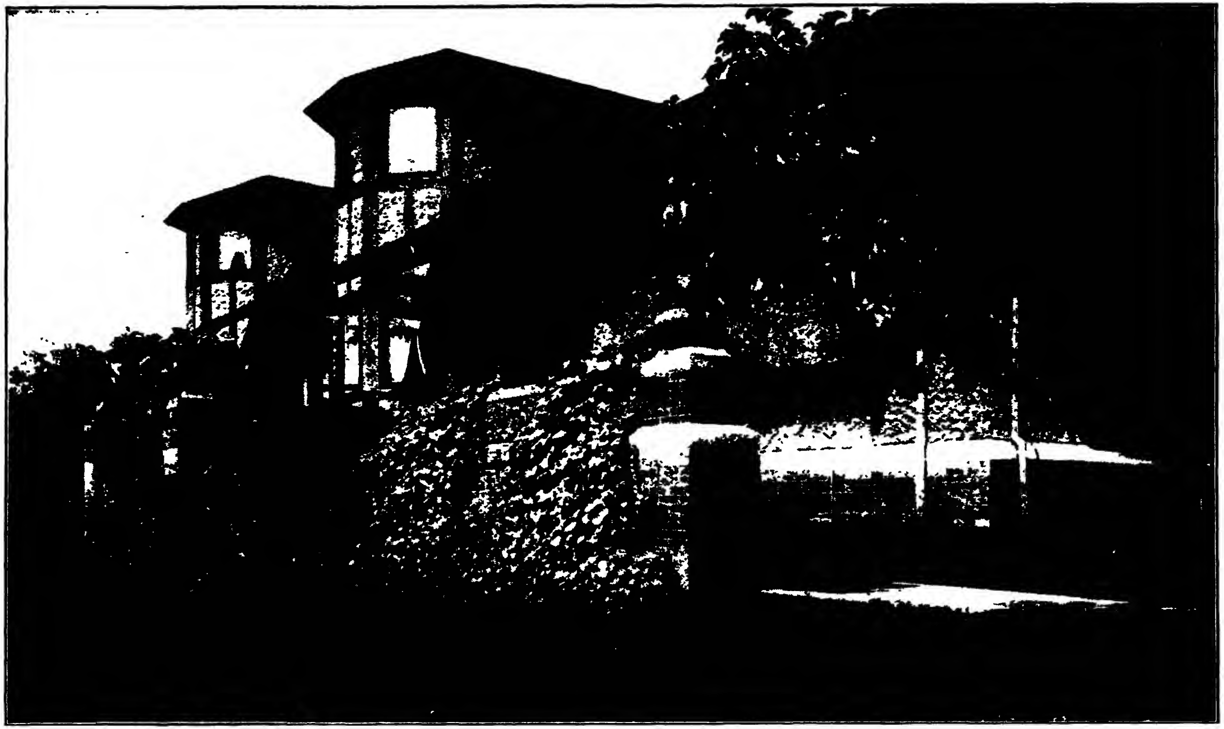
Drawings form a very important part in sheet-metal architectural



FRONT ELEVATION SIDE ELEVATION

Fig. 260.

work. An *elevation* is a geometrical projection of a building or other object, on a plane perpendicular to the horizon—as, for example, Figs. 259 and 263. Elevations are ordinarily drawn to a scale of ¼ or



HOUSE AT PARKERSBURG, W. VA.

R. C. Spencer, Jr., Architect, Chicago, Ill.

Red Brick to Water Table. Rough-Cast Plaster on Metal Lath on Stud Frame above Water Table. Woodwork is Undressed Stained Shingle Roofs.

½ inch to the foot. A *sectional drawing* shows a view of a building or other object as it would appear if cut in two at a given vertical line—as, for example, Fig. 255. *Detail drawings* are ordinarily full size, and

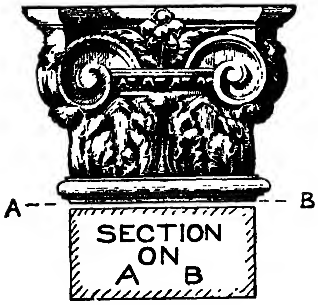


Fig. 261.

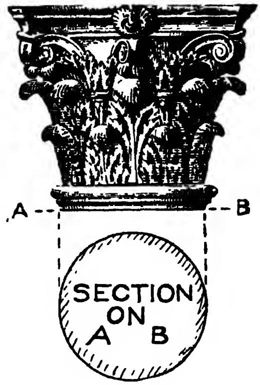


Fig 262.

are often called *working drawings*. *Tracings* are duplicate drawings, made by tracing upon transparent cloth or paper placed over the orig-

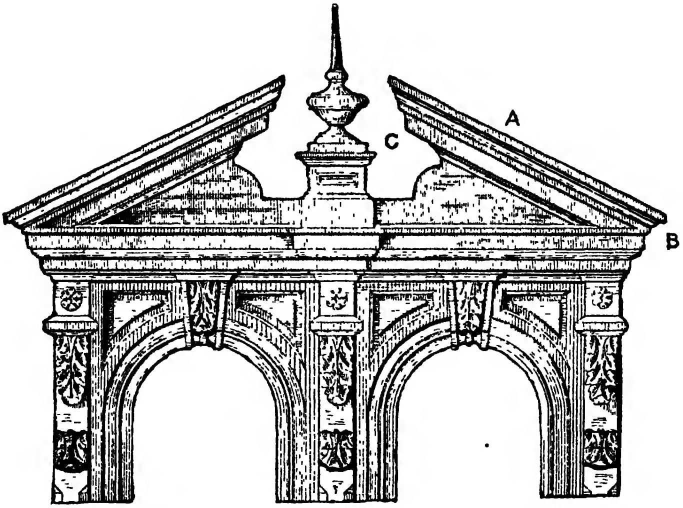


Fig. 263.

inal drawing. Many other terms might be introduced here; but enough, we believe, have been presented to give the student the leading general points.

A few words are necessary on the subject of *fastening the cornice to the wall.*

Sheet-metal cornices are made of such a wide range of sizes, and are required to be placed in so many different locations, that the methods of construction, when wooden lookouts are employed and

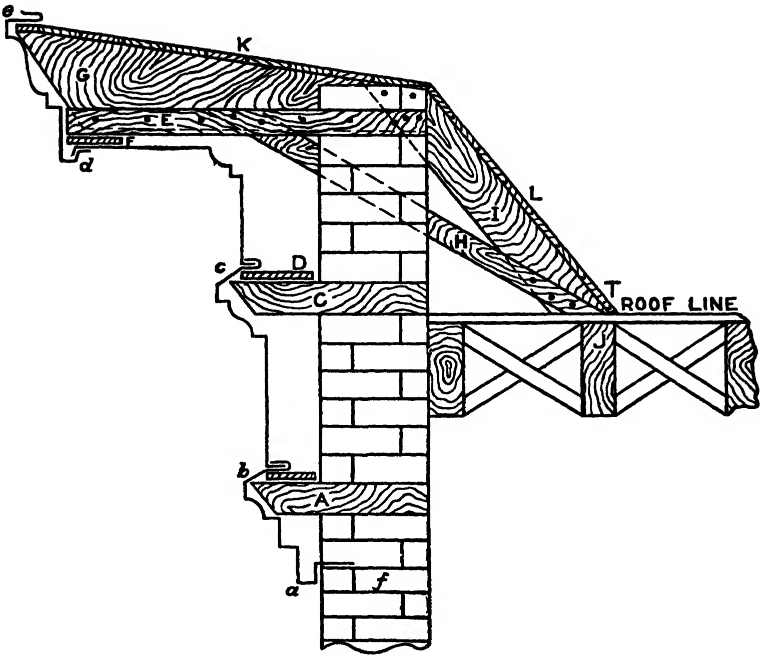


Fig. 264.

when the cornice is put together at the building in parts, are worthy of the most careful study. The general order of procedure in putting up, is as follows:

The foot-moulding or architrave *a b* (Fig. 264) is set upon the wall finished up to *f*, the drip *a* being drawn tight against the wall. The brickwork is then carried up, and the lookout A placed in position, the wall being carried up a few courses higher to hold the lookout in position. A board B is then nailed on top of the lookouts (which should be placed about three feet apart); and on this the flange of the foot-mould *b* is fastened. The frieze or panel *b c* is now placed into the lock B, which is closed and soldered; when the lookout C and the board D are placed in their proper positions, as before described.

The planceer and bed-mould *c d* are now locked and soldered at D, and the lookout E placed in position, with a board F placed under the lookouts the entire length of the cornice; onto this board the planceer is fastened. Having the proper measurements, the framer now constructs his lookouts or brackets G H I E, fastening to the beam at T, when the crown-mould *d e* is fastened to the planceer, through the flange of the drip at *d*, and at the top at *e*. The joints between lengths of mouldings, are made by lapping, riveting, or bolting, care being taken that they are joined so neatly as to hide all indications of a seam when finished and viewed from a short distance.

If brackets or modillions are to be placed in position, they are riveted or bolted in position; or sometimes the back of the cornice is blocked out with wood, and the brackets screwed in position through their flanges.

While a galvanized-iron cornice thus constructed on wooden lookouts will resist fire for a long time, a strictly fireproof cornice is obtained only by the use of metal for supports and fastenings, to the entire exclusion of wood. This fireproof method of construction is shown in Fig. 265. Instead of putting up in parts on the building, the cornice is constructed in one piece in the shop or upon the ground, and hoisted to the top of the wall in long lengths easily handled. A drip *a* is used at the bottom of the foot-mould, and the joints made in the way indicated at *b* and *c*, with a lock at *d*. Band iron supports and braces are used, formed to the general contour of the parts as shown by A B C, and bolted direct to the cornice, as shown, before hoisting.

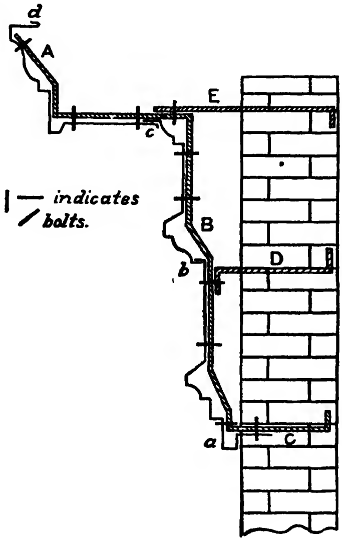


Fig. 265.

When the cornice sets on the wall as at C, anchors are fastened to the main brace, as at D and E, with an end bent up or down for fastening. If the cornice sets perfectly plumb, the mason carries up his wall, which holds the cornice in a firm position. The top and back are then framed in the usual manner and covered by the metal

roofer. In constructing cornices in this manner, the mouldings are run through solid, behind all brackets and modillions. The brackets and modillions are attached by means of riveting through outside flanges.

SHOP TOOLS

One of the most important tools in cornice or architectural sheet-metal working shop is the *brake*. On those operated by hand, sheets are bent up to 8 feet in one continuous length. In the larger shops, power presses or brakes are used, in which sheets are formed up to 10 feet in length, the press being so constructed that they will form ogees, squares, or acute bends in one operation.

Large 8- or 10-feet *squaring shears* also form an important addition to the shop, and are operated by foot or power.

When cornices are constructed where the planceer or frieze is very wide, it is usual to put crimped metal in, to avoid the waves and buckles showing in the flat surface; for this purpose the *crimping machine* is used.

In preparing the iron braces for use in the construction of fireproof cornices, a *punching machine* and *slitting shears* are used for cutting the band iron and punching holes in it to admit the bolts. While braces are sometimes bent in a vise, a small machine known as a *brace bender* is of great value in the shop. In large fireproof building constructions, it is necessary that all doors, window frames, and even sashes be covered with metal, and made in so neat a manner that, when painted and grained, no differences will be apparent to indicate whether the material is wood or metal, the smallest bends down to $\frac{1}{8}$ inch being obtained. This, of course, cannot be done on the brakes just mentioned, but is done by means of the *draw-bench*, which is constructed in lengths up to 20 feet and longer, operated by means of an endless chain, and capable of drawing the sheet metal over any shaped wood mould as tightly as if it were cast in one piece. The smaller tools in the shop are similar to those described in the Instruction Papers on Tinsmithing and Sheet Metal Work, Part I.

METHOD EMPLOYED FOR OBTAINING PATTERNS

The principles applied to cylinder developments as explained in the Tinsmithing and Sheet Metal Work courses, under the heading of "Parallel-Line Developments," are also applicable for obtaining

the patterns for any moulding where all members run parallel; for it makes no difference what profile is employed, so long as the lines run parallel to one another, the parallel-line method is used. While this method is chiefly employed in cornice work, other problems will arise, in which the "Radial-Line" and Triangulation" methods (explained in previous Papers) will be of service.

The term generally used in the shop for pattern cutting on cornice work is *miter cutting*. To illustrate, suppose two pieces of mouldings are to be joined together at angle of 90°, as shown in Fig. 266. The first step necessary would be to bisect the given angle and obtain the *miter-line* and cut each piece so that they would miter together. If a carpenter had to make a joint of this kind, he would place his moulding in the miter-box, and cut one piece right and one piece left at an angle of 45°, and he would be careful to hold the moulding in its proper position before sawing; or else he may, instead of having a return miter as shown, have a face miter as in a picture frame, shown in Fig. 267. The sheet-metal cornice-maker cannot, after his moulding is formed, place it in the miter-box to cut the miter, but must lay it out—or, in other words, develop it—on a flat surface or sheet of metal. He must also be careful to place the profile in its proper position with the miter-line; or else, instead of having a return miter as shown in Fig. 266, he will have a face miter as shown in Fig. 267. If he lays out his work correctly, he can then cut two pieces, form one right and the other left, when a miter will result between the two pieces of moulding and will look as shown in Fig. 266. If, however, a face miter is desired, as shown in Fig. 267, which is used when miters are desired for panels and other purposes, the method of laying them out will be explained as we proceed. The same principles required for developing Figs. 266 and 267 are used, whether the mouldings are mitered at angles of 90°

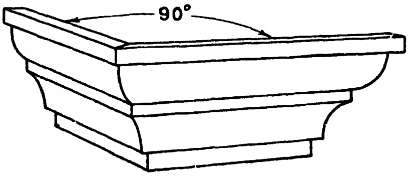


Fig. 266.

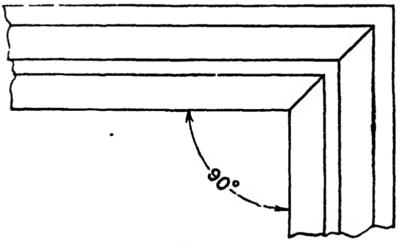


Fig. 267.

or otherwise. The method of *raking* the mouldings—or, in other words, changing their profile to admit the mitering of some other moulding at various angles—will also be thoroughly explained as we proceed.

VARIOUS SHAPES OF MOULDINGS

The style of mouldings arising in the cornice shop are chiefly Roman, and are obtained by using the arcs of a circle. In some cases, Greek mouldings are used, the outlines of which follow the curves of conic sections; but the majority of shapes are arcs of circles. In

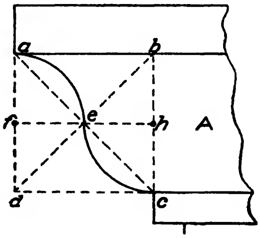


Fig. 268.

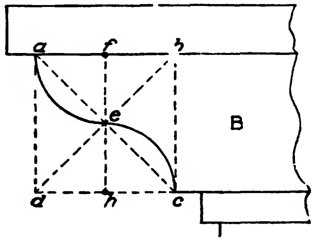


Fig. 269.

Figs. 268 to 272 inclusive, the student is given a few simple lessons on Roman mouldings, which should be carefully followed. As all pattern-cutters are required to draw their full-size details in the shop from small-scale drawings furnished by the architect, it follows that they must understand how to draw the moulds with skill and ease; other-

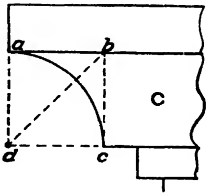


Fig. 270.

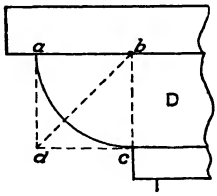


Fig. 271.

wise freehand curves are made, which lack proportion and beauty.

In Fig. 268, A shows the mould known as the *cyma recta*, known in the shop as the *ogee*, which is drawn as follows:

Complete a square *a b c d*; draw the two diagonals *a c* and *b d*, intersecting each other at *c*. Through *e*, draw a horizontal line intersecting *a d* at *f* and *b c* at *h*. Then, with *f* and *h* as centers, draw respectively the two quarter-circles *a e* and *c c*.

In Fig. 269, B shows the *cyma reversa,* known in the shop as the *ogee,* reversed. Complete a square *a b c d,* and draw the two diagonals *b d* and *a c* intersecting at *e*; through *e,* draw a vertical line intersecting *a b* at *f* and *c d* at *h,* which points are the respective centers for the arcs *a e* and *e c.*

C in Fig. 270 shows the *cavetto,* called the *cove* in the shop, which is drawn by completing a square *a b c d.* Draw the diagonal *b d* at 45°, which proves the square; and, using *d* as a center, draw the quarter-circle *a c.*

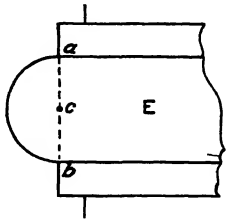


Fig. 272.

In Fig. 271, D represents the *ovolo* or *echinus,* known in the shop as the *quarter-round,* which is constructed similarly to C in Fig. 270, with the exception that *b* in Fig. 271 is used to obtain the curve *a c.*

E in Fig. 272 is known as the *torus,* known in the shop as a *bead-mould.* A given distance *a b* is bisected, thus obtaining *c,* which is the center with which to describe the semicircle *a b.*

All of these profiles should be drawn by the student to any desired scale for practice. In preparing mouldings from sheet metal,

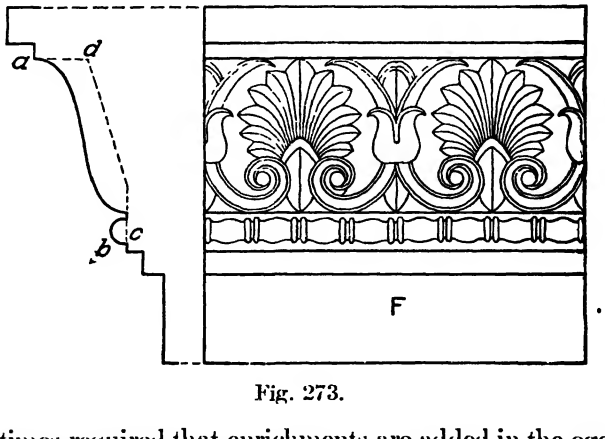


Fig. 273.

it is sometimes required that enrichments are added in the ogee, cove, and bead. In that case the mould must be bent to receive these enrichments, which are usually obtained from dealers in stamped or pressed sheet-metal work. Thus, in Fig. 273, F represents a front view of a crown mould whose ogee is enriched. the section of the en-

richment being indicated by *a b* in the section, in which the dotted line *d c* shows the body of the sheet-metal moulding bent to receive the pressed work. In Fig 274, H represents part of a bed-mould in which

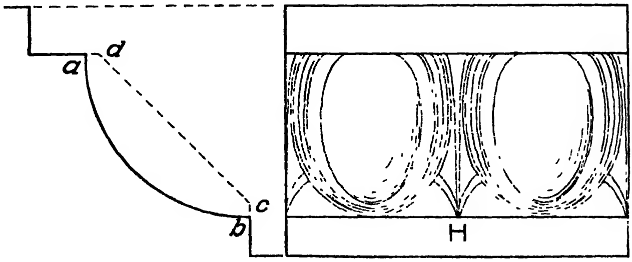


Fig. 274.

egg-and-dart enrichments are placed. In this case the body of the mould is bent as shown by *c d* in the section, after which the egg-and-dart is soldered or riveted in position. J in Fig. 275 represents part

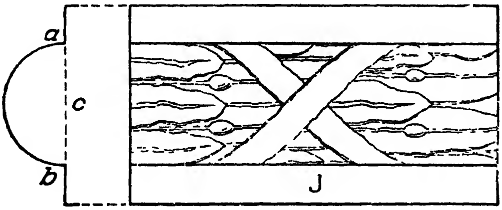


Fig 275.

of a foot-mould on which an enriched bead is fastened. The body of the mould would be formed as indicated by *c* in the section, and the bead *a b* fastened to it. This same general method is employed, no matter what shape the pressed work has.

PRACTICAL MITER CUTTING

Under this heading come the practical shop problems. The problems which will follow should be drawn to any desired scale by the student, developed, and bent from stiff cardboard to prove the accuracy of the pattern. If the student cannot use the small brake in the shop and test his patterns cut from metal, he can use the dull blade of a table knife, over which the bends can be made, when using cardboard patterns. This at once proves interesting and instructive. Should there be any problem which is not clear, he should write at once for further information; or, should any problem arise on which he desires

information, the School will inform him which problem in his text-books contains similar principles, or will prepare such a problem for him.

The first problem will be to obtain the development of a square return miter, such as would occur when a moulding had to return around the corner of a building, as shown in Fig. 276. In Fig. 277 are shown two methods of obtaining the pattern. The first method which will be described is the "long" method, in which are set forth all the principles applicable to obtaining patterns for mouldings, no matter what angle the plan may have. The second method is the "short'

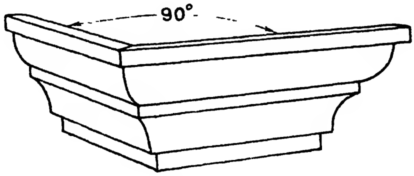


Fig. 276.

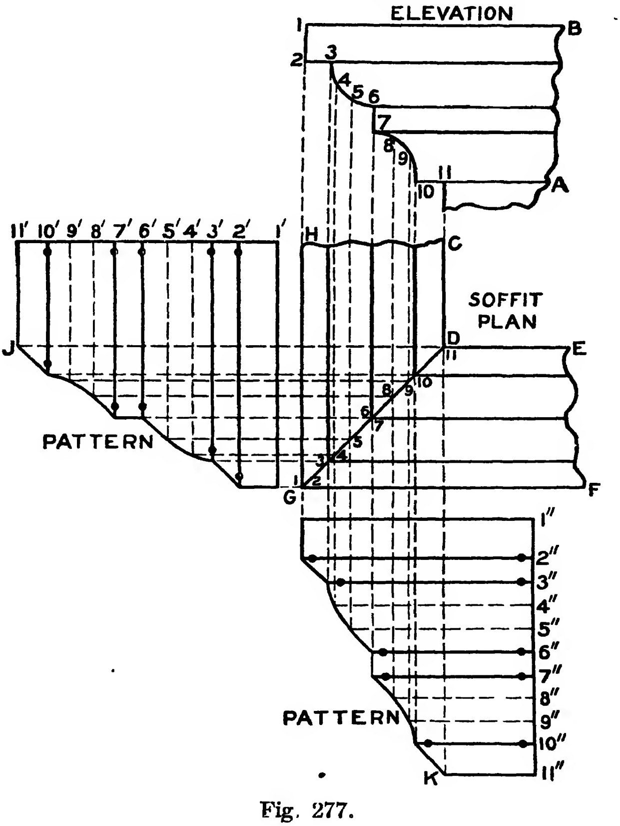


Fig. 277.

rule generally employed in the shop, which, however, can be used only when the angle H G F in plan is 90°, or a right angle.

To obtain the pattern by the first method, proceed as follows: First, draw the elevation of the mould as shown by 1, B, A, 11, drawing the coves by the rule previously given. Divide the curves into equal spaces; and number these, including the corners of the fillets as shown by the small figures 1 to 11. In its proper position below the elevation, draw the soffit plan as shown by C D E F G H. Bisect the angle H G F by the line G D, which is drawn at an angle of 45°. From the various intersections in the elevation, drop lines intersecting the miter-line as shown. At right angles to H G, draw the stretchout line 1′ 11′, upon which place the stretchout of the mould 1 11 in elevation, as shown by similar figures on the line 1′ 11′. At right angles to 1′ 11′, and from the numbered points thereon, draw lines, which intersect by lines drawn at right angles to H G from similarly numbered intersections on the miter-line G D. Trace a line through the intersections

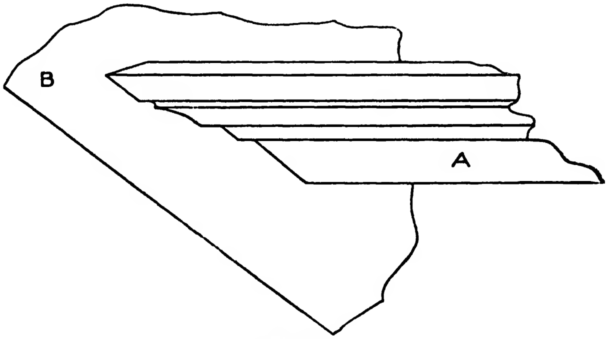


Fig. 278.

thus obtained, as shown by J G. Then will 1′ G J 11′ be the desired pattern. This gives the pattern by using the miter-line in plan.

In developing the pattern by the short method, on the other hand, the plan is not required. At right angles to 1 B in elevation, draw the stretchout line 1″ 11″, upon which place the stretchout of the profile 1 11 in elevation, as shown by similar figures on 1″ 11″, at right angles to which draw lines through the numbered points as shown, which intersect by lines drawn at right angles to 1 B from similarly numbered intersections in the profile in elevation. Trace a line through points thus obtained, as shown by G K. Then will G 1″ 11″ K be similar to J G 1′ 11′ obtained from the plan,

In Fig. 278 is shown a horizontal moulding butting against a plane surface oblique in elevation. A miter cut of this kind would be required when the return moulding of a dormer window would butt against a mansard or other pitched roof. In this case we assume A to be the return butting against the pitched roof B. The method of

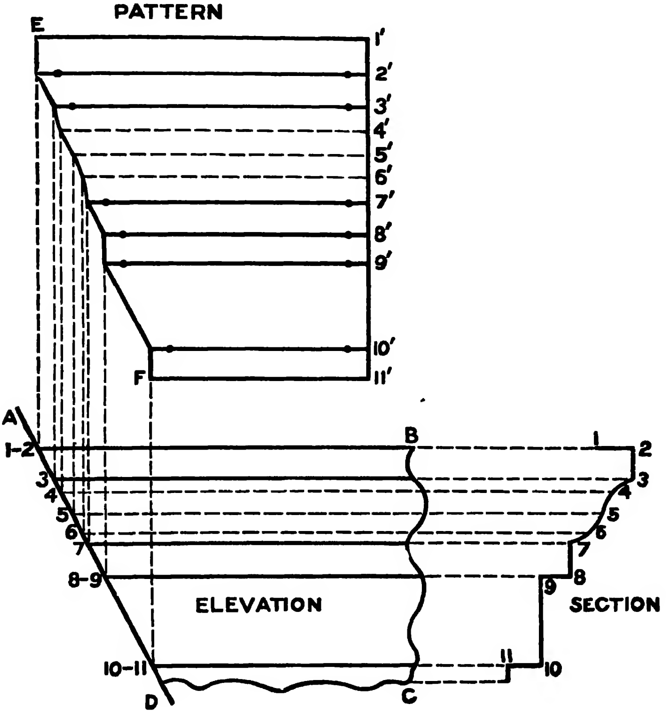


Fig. 279.

obtaining a pattern of this kind is shown in Fig. 279. Let A B C D represent the elevation of the return, A D representing the pitch of the roof. In its proper position as shown, draw the section 1 11, which divide into equal spaces as shown, and from which, parallel to A B, draw lines intersecting the slant line A D from 1 to 11, as shown. At right angles to A B erect the stretchout line 1′ 11′, upon which place the stretchout of the section as shown by similar figures on 1′ 11′. At right angles to 1′ 11′, and through the numbered points thereon, draw lines, which intersect by lines drawn at right angles to A B from similarly numbered intersections on the slant line A D. Through

the various intersections thus obtained, draw E F. Then will E F 11′ 1′ be the desired pattern.

It is sometimes the case that the roof against which the moulding butts, has a curved surface either concave or convex, as shown by B C in Fig. 280, which surface is convex. Complete the elevation of the moulding, as D E; and in its proper position draw the section 1 9, which divide into equal spaces as shown by the small figures, from which draw horizontal lines until they intersect the curved line B C, which is struck from the center point A. At right angles to the line of the moulding erect the line 1′ 9′, upon which place the stretchout

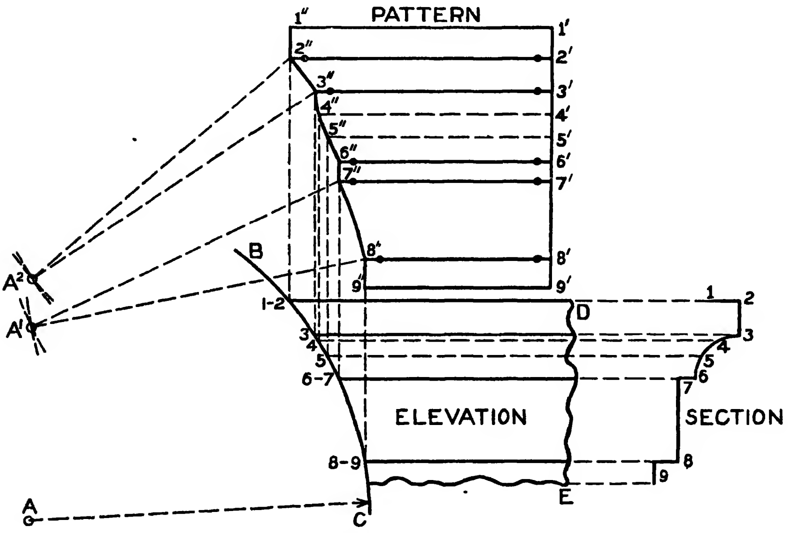


Fig 280

of the section, as shown by the figures on the stretchout line. Through the numbered points, at right angles to 1′ 9′, draw lines, which intersect by lines drawn at right angles to 2 D from similarly numbered intersections on the curve B C, thus resulting in the intersections 1″ to 9″ in the pattern, as shown. The arcs 2″ 3″ and 7″ 8″ are simply reproductions of the arcs 2 3 and 7 9 on B C. These arcs can be traced by any convenient method; or, if the radius A C is not too long to make it inconvenient to use, the arcs in the pattern may be obtained as follows: Using A C as radius, and 7″ and 8″ as centers, describe arcs intersecting each other at A^1; in similar manner, using 2″ and 3″ as centers, and with the same radius, describe arcs intersecting each

other at A^2. With the same radius, and with A^1 and A^2 as centers, draw the arcs 8″ 7″ and 3″ 2″ respectively. Trace a line through the other various intersections as shown. Then will 1′ 1″ 9″ 9′ be the desired pattern.

In Fig. 281 is shown an elevation of an oblong or rectangular panel for which a miter-cut is desired on the line *a b*—known as a "panel" or "face" miter. The rule to apply in obtaining this pattern is shown in Fig. 282. A shows the part elevation of the panel; *a b* and *c d*, the miter-lines drawn at angles of 45°. In its proper position with the lines of the moulding, draw the profile B, the curve or mould of which divide into equal spaces, as shown by the figures 1 to 7; and from the points thus obtained, parallel to 1 *b*, draw lines intersecting the miter-line *a b* as shown. From these intersections, parallel to *b d*, draw lines intersecting also *c d*. At right angles to *b d* draw the stretchout line 1′ 7′, upon which place the stretchout of the profile B. At right angles to 1′ 7′, and through the numbered points of division, draw lines, which intersect by lines drawn at right angles to *b d* from similarly numbered intersections on the miter-lines *a b* and *c d*. Trace lines through the various points of intersection in the pattern as shown. Then will C D E F be the required cut for the ends of the panel.

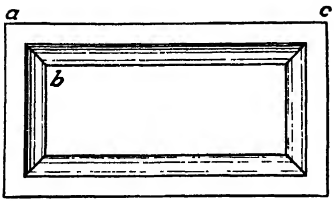


Fig. 281.

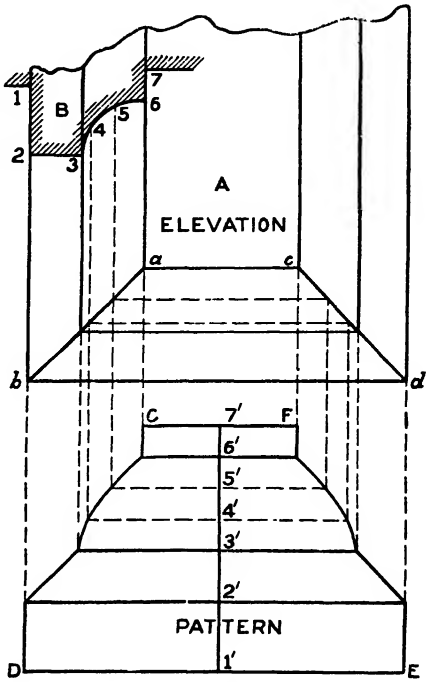


Fig 282.

The same miter-cuts would be employed for the long side *a c* in

Fig. 281, it being necessary only to make D E in Fig. 282 that length when laying out the patttern on the sheet metal.

Where the miter-cut is required for a panel whose angles are other than right angles, as, for example, a triangular panel as shown in Fig. 283, then proceed as shown in Fig. 284. First draw the elevation of the triangular panel as shown by A B C, the three sides in the case being equal. Bisect each of the angles A, B, and C, thus obtaining the miter-lines A *c*, B *b*, and C *a*. In line with the elevation, place in its proper position the profile E, which divide into equal spaces as shown; and from the numbered division points, parallel to A C, draw lines cutting the miter-line C *a*. From these intersections, parallel to C B, draw lines intersecting the miter-line *b* B. At right angles to C B draw the stretchout line 1′ 7′, upon which place the

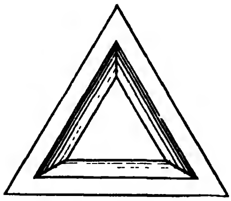


Fig. 283.

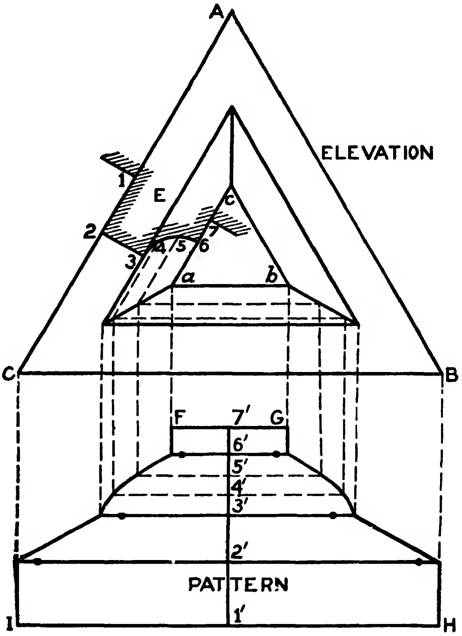


Fig. 284.

stretchout of the profile E. Through the numbered points of division and at right angles to 1′ 7′, draw lines as shown, which intersect by lines drawn at right angles to C B from intersections of similar numbers on the miter-lines *a* C and *b* B. Through the points thus obtained, trace the pattern F G H I.

It makes no difference what shape or angle the panel may have; the principles above explained are applicable to any case.

In ornamental cornice work, it often happens that tapering moulded panels are used, a plan and elevation of which are shown in Fig. 285.

By referring to the plan, it will be seen that the four parts *b a*, *a b′*, *b′ a′*, and *a′ b* are symmetrical; therefore, in practice, it is necessary only to draw the one-quarter plan, as shown in Fig. 286, and omit the elevation, since the height *d e* (Fig. 285) is known. Thus, in Fig. 286, draw the quarter-plan of the panel, no matter what is its shape, as shown

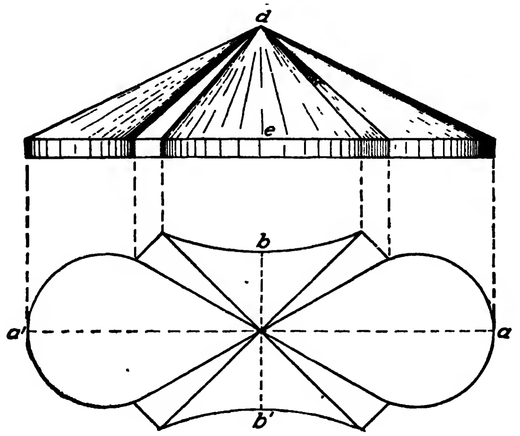


Fig. 285.

by *a* 1 5 6 9. Divide the curves from 1 5 and 6 9 into equal spaces, indicated respectively by 1, 2, 3, 4, and 5, and 6, 7, 8, and 9. From these points, draw lines to the apex *a*. As the pattern will be developed by triangulation, a set of triangles will be required, as shown in

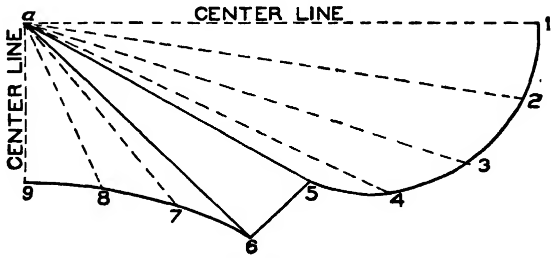


Fig. 286.

Fig. 287, for which proceed as follows: Draw any horizontal line, as *a* 1; and from *a* erect the perpendicular *a a′* equal to the height the panel is to have. Now take the lengths of the various lines in Fig. 286 from *a* to 1, *a* to 2, *a* to 3, etc., to *a* to 9, and place them on the line *a* 1 in Fig. 287, as shown by similar numbers. Then using as radii the various

lengths a' 1, a' 2, a' 3, etc., to a' 9, and with any point, as a' in Fig. 288 as center, describe the various arcs shown from 1 to 9. From any point on the arc 1 draw a line to a'. Set the dividers equal to the spaces contained in the curve 1 5 in Fig. 286; and, starting from 1 in Fig. 288 step from one arc to another having similar numbers, as shown from 1 to 5. In similar manner, take the distance from 5 to 6 and the spaces in the curve 6 9 in Fig. 286, and place them on corresponding arcs in Fig. 288, stepping from one arc to the other, resulting in the points 5 to 9. Trace a line through the points thus obtained. Then will a' 1 5 6 9 a' be the quarter-pattern, which can be joined in one-half or whole pattern as desired.

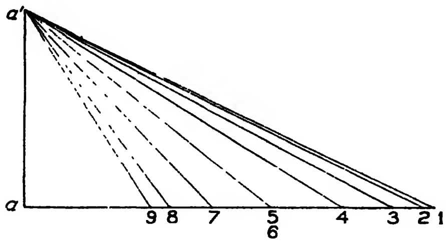


Fig. 287.

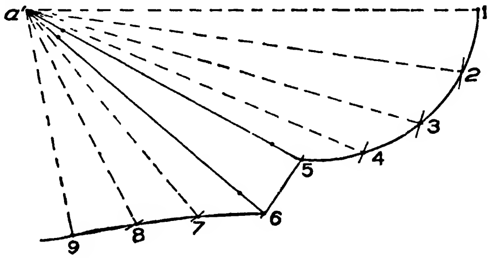


Fig. 288.

In Fig. 289 is shown a perspective of a moulding which miters at an angle other than a right angle. This occurs when a moulding is required for over a bay window or other structure whose angles vary. The rule given in Fig. 290 is applicable to any angle or profile. First draw a section or an elevation of the moulding as shown by A B 14 1. Directly below the moulding, from its extreme point, as 2 3, draw a plan of the desired angle as shown by C 2 D. Bisect this angle by using 2 as center and, with any radius, describing an arc meeting the sides of the angle at C and E. With the same or any other radius, and with C and E as centers, describe arcs intersecting each other in F. From the corner 2, draw a line through F. Then will 2 H be the

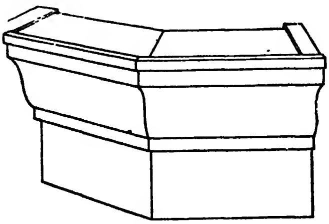
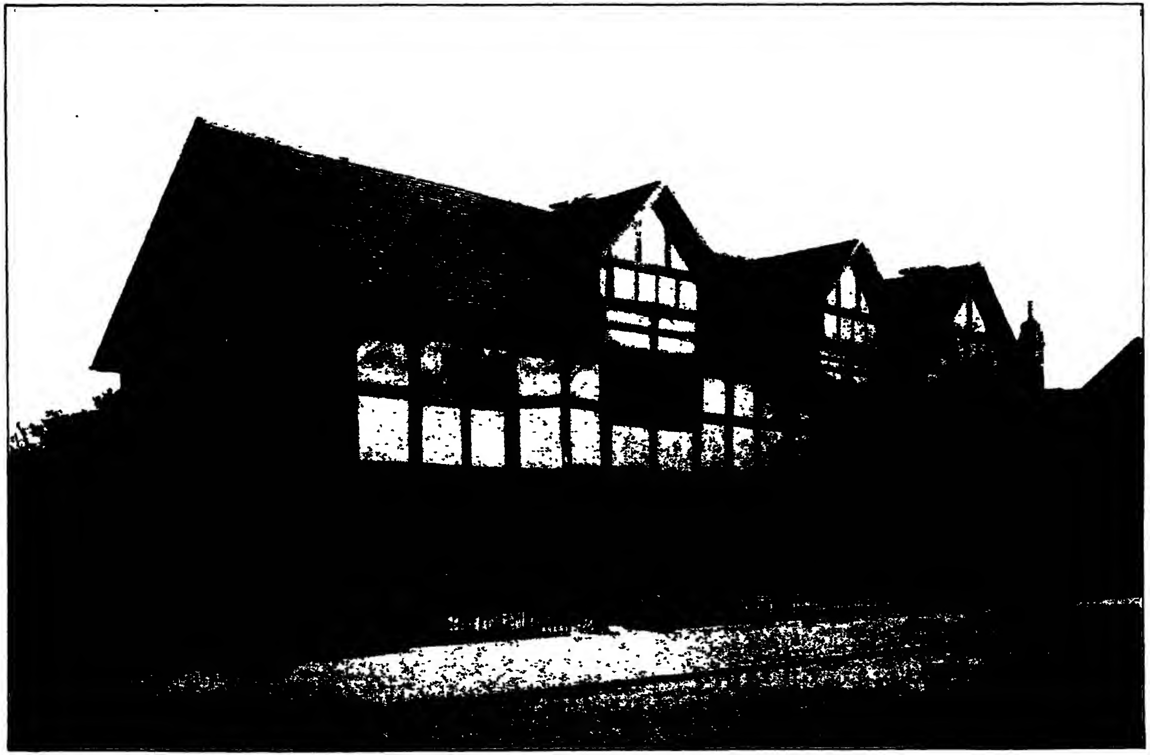


Fig. 289.



SHAKESPEARE'S HOUSE AT STRATFORD-ON-AVON
Here Shakespeare was Born, April 23, 1564. Building Restored in 1857.

miter-line, or the line bisecting the angle C 2 D. Now divide the profile 1 14 into equal spaces as shown by the figures, and from the points thus obtained drop vertical lines intersecting the miter-line 2

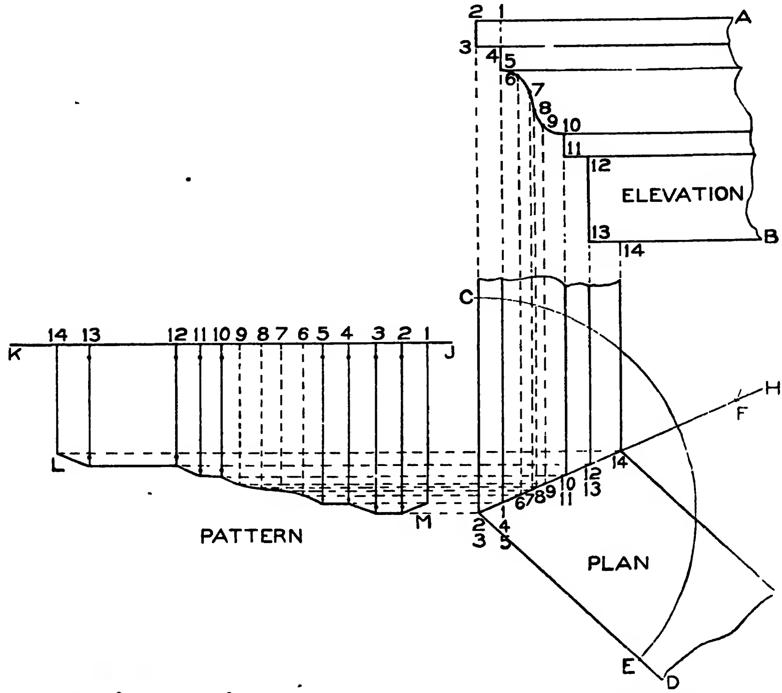


Fig. 290.

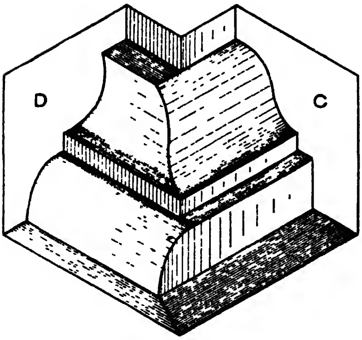


Fig. 291.

H in plan from 1 to 14 as shown. At right angles to C 2, draw the line J K, upon which place the stretchout of the profile in elevation as shown by similar figures on the stretchout line, through which drop lines perpendicular to J K, which intersect with lines drawn parallel to J K from similarly numbered points of intersection on the miter-line 2 H. Trace a line as shown by L M, which is the miter-cut desired.

When two mouldings having different profiles are required to miter together as shown in Fig. 291, where C miters at right angles

with D, two distinct operations are necessary, which are clearly shown in Figs. 292 and 293. The first operation is shown in Fig. 292, in which C represents the elevation of an ogee moulding which is to miter at right angles with a moulding of different profile as shown at D. Divide the profile C into equal spaces, from which points draw horizontal lines intersecting the moulding D from 1′ to 10′. At right angles to the line of the moulding C, draw the line A B, upon which place the stretchout of the profile C as shown by similar figures on A B. At right angles to A B, and through the points indicated by the figures, draw lines, which intersect with lines drawn parallel to A B from similarly numbered intersections in the profile D. Trace a line through the points thus obtained, as shown by E H. Then will E F G H be the pattern for C in elevation.

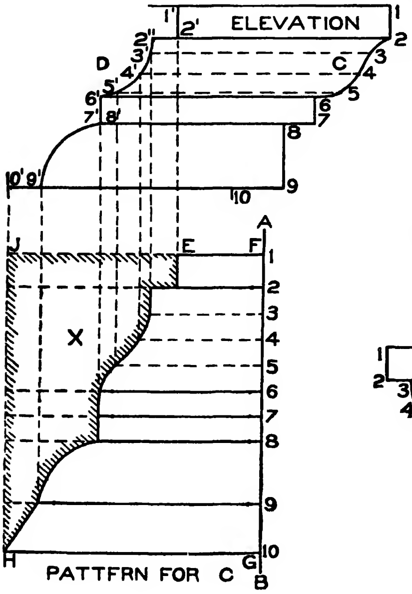


Fig. 292.

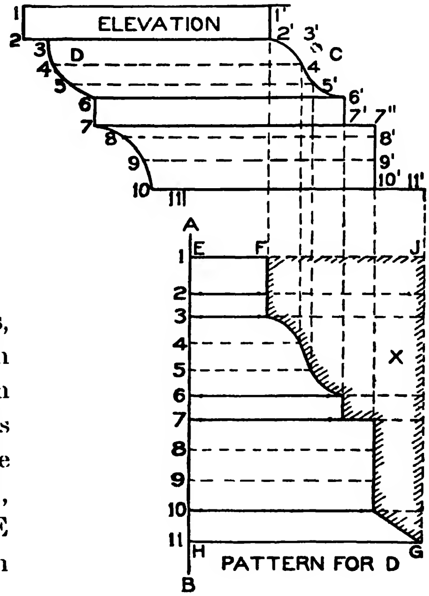


Fig. 293.

To obtain the pattern for D, draw the elevation of D (Fig. 293), which is to miter at right angles with a moulding whose profile is C. Proceed in precisely the same manner as explained in connection with Fig. 292. Divide the profile D in Fig. 293 into equal parts, as shown, from which draw horizontal lines cutting the profile C. At right angles

to the lines of the moulding D, draw the stretchout line A B, upon which place the stretchout of the profile D. At right angles to A B, and through the numbered points of division, draw lines as shown, which intersect by lines drawn parallel to A B from similarly numbered intersections in the profile C. Through these points of intersection draw F G. Then will E F G H be the desired pattern for D.

It should be understood that when the patterns in Figs. 292 and 293 are formed and joined together, they will form an inside miter, as is shown in Fig. 291. If, however, an outside miter were required, it would be necessary only to use the reverse cuts of the patterns in Figs. 292 and 293, as shown by E J H in Fig. 292 for the mould C, and F J G in Fig. 293 for the mould D.

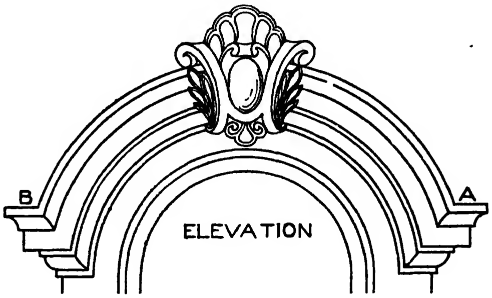


Fig. 294.

When joining a curved moulding with a straight moulding in either plan or elevation even though the curved or straight mouldings each have the same profile, it is necessary to establish the true miter-line before the pattern can be correctly developed, an example being given in Fig. 294, which shows an elevation of a curved moulding which is intersected by the horizontal mouldings A B. The method of obtaining this miter-line, also the pattern for the horizontal pieces, is clearly shown in Fig. 295. First draw the profile which the horizontal moulding is to have, as 1 10. Let the distance 9 B be established. Then, with C on the center line as center, and A C as radius, describe the arc B A. From any point on the line 9 B, as *a*, erect the vertical line *a b*. Through the various divisions in the profile 1 10, draw horizontal lines intersecting the vertical line *a b* from 1 to 10 as shown. From the center C, draw any radial line, as C *d*, cutting the arc B A at *e*. Now take the various divisions on *a b*, and place them from *e* to *d* as shown by points 1′ to 10′. Then, using C as center, with radii determined by the various points on *e d*, draw arcs intersecting horizontal lines of similar numbers drawn through the divisions on *a b*. Through

these points of intersection, draw the miter-line shown. The student will note that this line is irregular.

Having obtained the miter-line, the pattern is obtained for the horizontal moulding by drawing the stretchout line E F at right angles to 9 B. On E F lay off the stretchout of the profile 1 10; and through the numbered points and at right angles to E F, draw horizontal lines, which intersect with lines drawn at right angles to 9 B from similarly numbered intersections in the miter-line determined by horizontal lines already drawn through the vertical line *a b*. Trace a line through the points thus obtained, as shown by H I J K, which is the desired pattern.

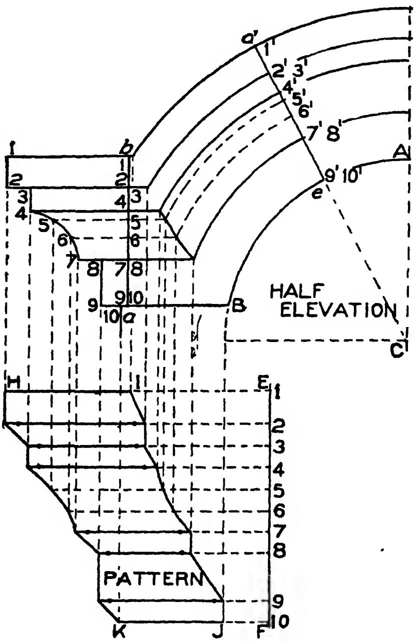


Fig. 295.

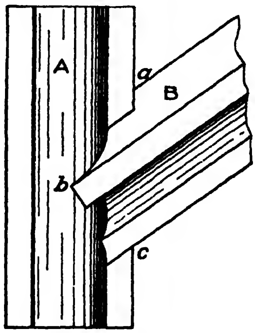


Fig. 296.

In Fig. 296 is shown a shaded view of a gable moulding intersecting a pilaster, the gable moulding B cutting against the vertical pilaster A, the joint-line being represented by *a b c*. To obtain this joint-line, without which the pattern for the gable moulding cannot be developed, an operation in projection is required. This is explained in Fig. 297, in which B C D shows the plan of the pilaster shown in elevation by E. In its proper position in plan, place the profile of the gable moulding, as shown by A, which divide into equal spaces as shown by the figures 1 to 8, through which draw horizontal lines intersecting the plan of the pilaster B C D as shown by similar figures. For convenience in pro-

jecting the various points, and to avoid a confusion of lines, number the intersections between the lines drawn from the profile A through the wash B 2, "7°", "4°", and "3°". At the desired point H in elevation, draw the lower line of the gable moulding, as H F. Take a tracing of the profile A in plan, with all of the various intersections on same, and place it in elevation as shown by A^1, placing the line 1 8 at right angles to H F. Through the various intersections 1, 7°, 4°, 3°, 2, 3, 4, 5, 6, 7, and 8 in A^1, and parallel to F H, draw lines indefinitely, which intersect by lines drawn at right angles to C B in plan from similarly numbered intersections in the pilaster C D B, thus obtaining the points of intersection 1^x to 8^x in elevation.

For the pattern, proceed as follows: At right angles to H F, draw the stretchout line J K, upon which place the stretchout of the profile A or A^1, with all the points of intersection on the wash 1 2. At right angles to J K, and through the numbered points, draw lines as shown, which intersect by lines drawn at right angles to H F from similarly numbered intersections in the joint-line 1^x 8^x Through the points thus obtained, trace the miter-cut M N O. Then will L M N O P be the pattern for the gable moulding.

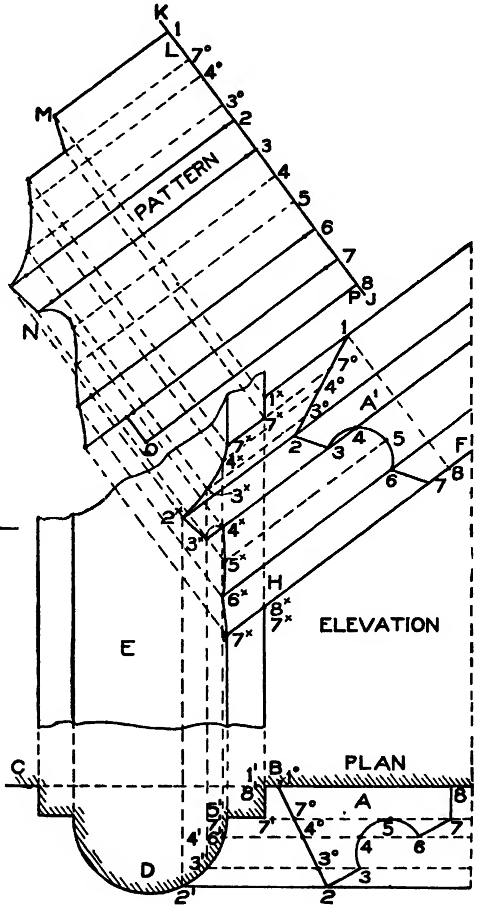


Fig. 297.

In Fig. 298 are shown gable mouldings mitering upon a wash. The

mouldings A A intersect at any desired angle the wash B. In this case, as in the preceding problem, an operation in projection must be gone through, before the pattern can be obtained. This is clearly shown

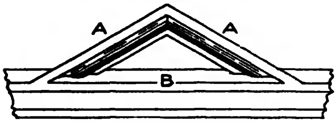


Fig. 298.

in Fig. 299. Draw the section of the horizontal moulding B^1 with the wash *a b*. From this section project lines, and draw the part elevation D C. Knowing the bevel the gable is to have, draw C B, in this case the top line of the moulding. Draw a section of the gable mould, as A, which divide into equal parts as shown from 1 to 8; and through the point of division draw lines parallel to B C, indefinitely, as shown. Take a tracing of the profile A, and place it in section as shown by A^1. Divide A into the same

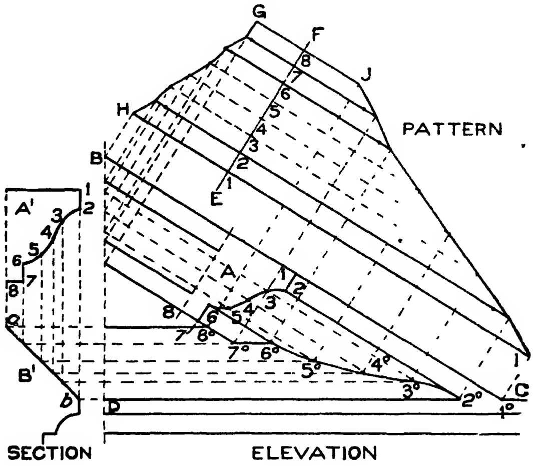


Fig. 299.

number of spaces as A; and from the various divisions in A^1 drop vertical lines intersecting the wash *a b* as shown, from which points draw horizontal lines intersecting lines drawn parallel to B C through similarly numbered points in A, at 1° to 8°. Trace a line through these intersections as shown, which represents the miter-line or line of joint in elevation.

For the pattern, draw any line as E F, at right angles to B C, upon which place the stretchout of the profile A, as shown by similar figures on the stretchout line E F. Through the numbered points of division and at right angles to E F, draw lines as shown, which intersect by

lines drawn at right angles to B C from similarly numbered intersections on 1° 8° and on the vertical line B D. A line traced through points thus obtained, as shown by G H I J, will be the desired pattern.

In Fig. 300 is shown a front view of a turret on which four gables are to be placed, as shown by A A; also the roofs over same, as shown by B B. The problem consists in obtaining the developments of the gable mouldings on a square turret. In developing this pattern, the half-elevation only is required, as shown in Fig. 301, in which first draw the center line E F; then establish the half-width of the turret, as C D, and draw the rake B C. At right angles to the line B C, and in its proper position as shown, draw the profile A, which divide into equal spaces as shown by the figures 1 to 6, through which, parallel to B C, draw lines intersecting the center line F E as shown; and extend the lines below C, indefinitely. Now take a tracing of the profile A, and place it in position as shown by A^1, being careful to have it spaced in the same number of divisions, as shown from 1 to 6, through which, parallel to D C, erect lines intersecting similarly numbered lines drawn through the profile A, thus obtaining the intersections 1° to 6°, through which a line is traced, which represents the line of joint at the lower end between the two gables.

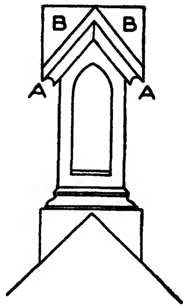


Fig. 300.

For the pattern, take a stretchout of A, and place it on the line J K drawn at right angles to B C, as shown by the figures 1 to 6 on J K. At right angles to J K, and through these points of division, draw lines, which intersect by lines drawn from similarly numbered intersections on F B and 1° 6°. Trace a line through the points thus obtained, as shown by F° B° C° 6°, which is the desired pattern, of which eight are required to complete the turret, four formed right and four left.

If the roof shown by B in Fig. 300 is desired to be added to the pattern in Fig. 301, then, at right angles to F° 6°, draw the line F° F^1 equal to F H in the half-elevation, and draw a line from F^1 to 6° in the pattern.

In Fig. 302 is shown front view of an angular pediment with horizontal returns at bottom A and top B. In this problem, as in others which will follow, a change of profile is necessary before the correct

pattern for the returns can be developed. In other words, a new profile must be developed from the given or normal profile before the patterns for the required parts can be developed. It should be understood that all given profiles are always divided into equal spaces; therefore the modified profiles will contain unequal spaces, each one of

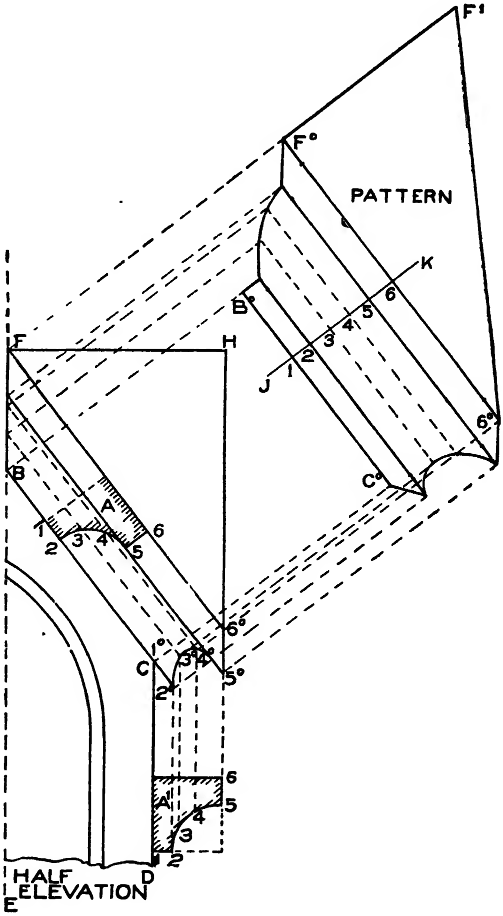


Fig. 301.

which must be carried separately onto the stretchout line. Bearing this in mind, we shall proceed to obtain the modified or changed profiles and patterns for the horizontal returns at top and foot of a gable moulding, as at B and A in Fig. 302, the given profile to be placed in the gable moulding C. In Fig. 303, let C represent the gable moulding

placed at its proper angle with the horizontal moulding G H. Assuming that 6^x 6^o is the proper angle, place the given profile A at right angles to the rake, as shown; and divide same into equal spaces as shown from 1 to 10, through which points, parallel to 6^x 6^o, draw lines towards the top and bottom of the raking moulding. Assuming that the length 6^x 6^o is correct, take a tracing of the profile A, and place it in a vertical position below at A^1 and above at A^2, being careful to have the points 6 and 6 in the profiles directly in a vertical position below the points 6^x and 6^o, as shown. From the various intersections in the profiles A^1 and A^2 (which must contain the same number of spaces as the given profile A), erect vertical lines intersecting lines drawn through the profile A, as shown at the lower end from 1^x to 10^x, and at the upper end from 1^o to 10^o. Trace a line through the points thus obtained. Then will 1^x 10^x be the modified profile for the lower horizontal return, and 1^o 10^o the modified profile for the upper horizontal return.

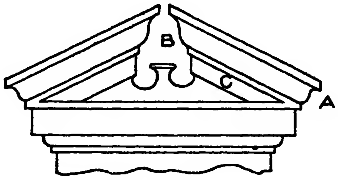


Fig. 303.

Note the difference in the shapes and spaces between these two modified profiles and the given profile A. It will be noticed that a portion of the gable moulding miters on the horizontal moulding G H from 6^x to $10'$.

For the pattern for the gable moulding, proceed as follows: At right angles to E F, draw the stretchout line J K, upon which place the stretchout of the given profile A, as shown by the figures 1 to 10 on J K. Through these figures, at right angles to J K, draw lines as shown, which intersect with lines drawn at right angies to E F from similarly numbered intersections in 1^o 10^o at the top and 1^x 6^x $10'$ at the lower end. Trace a line through the intersections thus obtained. Then will L M N O be the pattern for C.

For the pattern for the horizontal return at the top, draw a side view as shown at B, making P R the desired projection, and the profile 1 10 on B, with its various intersections, an exact reproduction of 1^o 10^o in the elevation. Extend the line R T as R S; and, starting from 10, lay off the stretchout of the profile in B as shown by the figures 1 to 10 on R S, being careful to measure each space separately. At right angles to R S draw the usual measuring lines, which intersect

by lines drawn parallel to S R from similarly numbered points in the profile in B. Trace a line through points thus obtained. Then will U V 10 1 be the pattern for the return B.

In similar manner, draw the side view of the lower horizontal return as shown at D, making the projection W 10 equal to P R

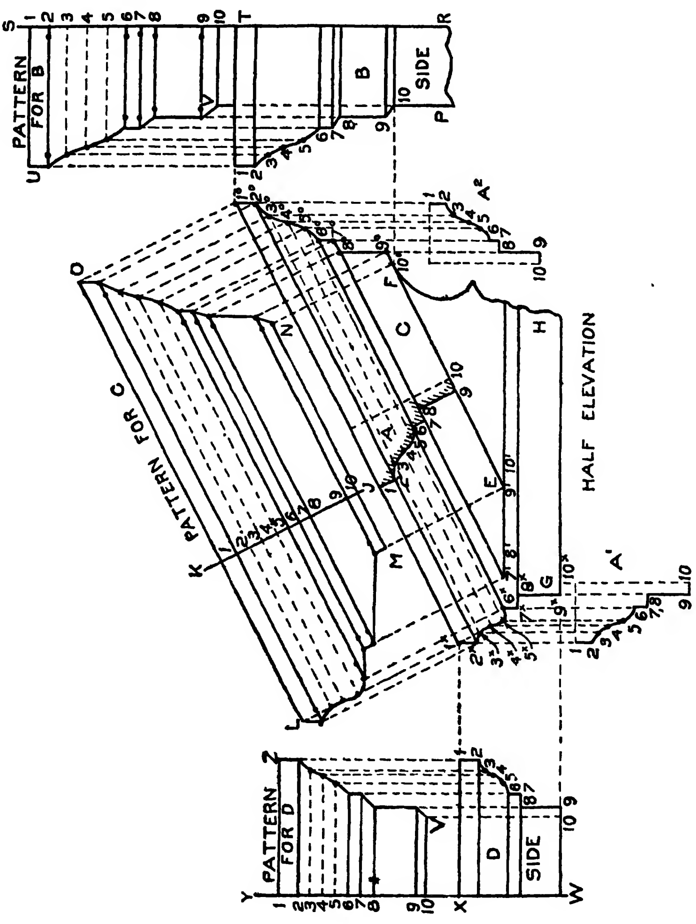


Fig. 303

in B. The profile shown from 1 to 10 in D, with all its divisions, is to be an exact reproduction of the profile 1^x to 10^x in elevation. Extend the line W X as X Y, upon which lay off the stretchout of the profile 1 10 in D, being careful that each space is measured separately, as they are all unequal. Through the figures on X Y draw lines as

shown, which intersect by lines drawn parallel to W Y from the various intersections in the profile in the side D. A line traced through points thus obtained, as shown by Z V, will be the desired cut, and 1 Z V 10 the pattern for the return D.

In Fig. 304 is shown a front view of a segmental pediment with upper and lower horizontal returns. This presents a problem of obtaining the pattern for horizontal returns at top and foot of a segmental pediment, shown respectively at A and B, the given profile to be placed in C. The principles used in obtaining these patterns are similar to those in the preceding problem, the only difference being that the moulding is curved in elevation. In Fig. 305 the true method is clearly given. First draw the center line B D, through which draw the horizon-

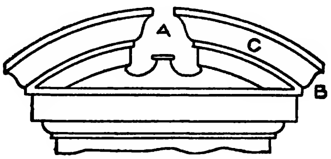


Fig. 304.

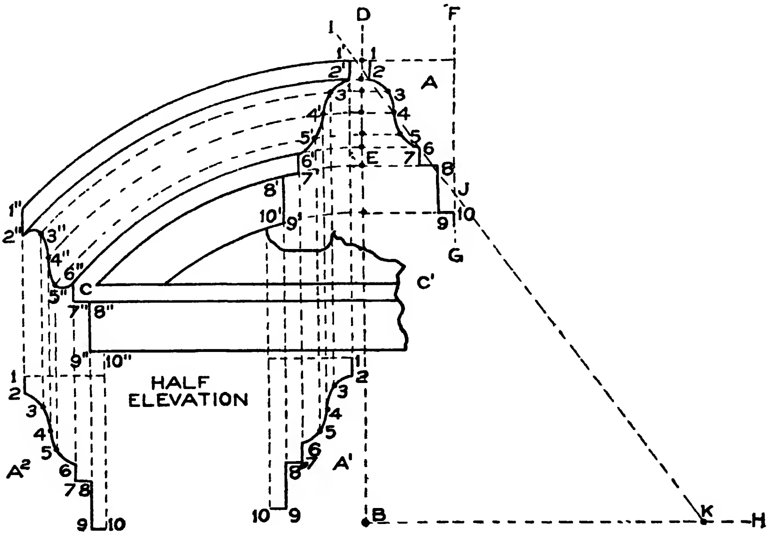


Fig 305.

tal line C C¹. From the line C C¹ establish the height E; and with the desired center, as B, draw the arc E C intersecting the line C¹ C at C. In its proper position on a vertical line F G, parallel to D B, draw the given profile of the curved moulding as shown by A, which divide into equal spaces as shown from 1 to 10. Through these figures, at right angles to F G, draw lines intersecting the center line D B as shown.

Then, using B as center, with radii of various lengths corresponding to the various distances obtained from A, describe arcs as shown, extending them indefinitely below the foot of the pediment. The point C or 6″ being established, take a tracing of the profile A, with all the various points of intersection in same, and place it as shown by A^2, being careful to have the point 6 in A^2 come directly below the point 6″ in elevation in a vertical position. Then, from the various intersections in A^2 erect vertical lines intersecting similarly numbered arcs drawn from the profile A. Trace a line as shown from 1″ to 10″, which is the modified profile for the foot of the curved moulding.

Establish at pleasure the point 1′ at the top, and take a tracing of the given profile A, placing it in a vertical position below 1′, as shown by A^1. From the various intersections in A^1 erect vertical lines intersecting similarly numbered arcs as before. Through these intersections, shown from 1′ to 10′, trace the profile shown, which is the modified profile for the top return.

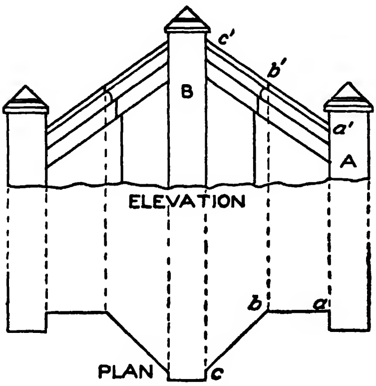


Fig. 306.

The curved moulding shown in elevation can be made either by hand or by machine. The general method of obtaining the blank or pattern for the curved moulding is to average a line through the extreme points of the profile A, as I J, extending it until it intersects a line drawn at right angles to D B from the center B, as B H, at K.

We will not go into any further demonstration about this curved work, as the matter will be taken up at its proper time later on.

To obtain the pattern for the upper and lower return mouldings, proceed in precisely the same manner as explained in connection with returns B and D in Fig. 303.

In Fig. 306 are shown the plan and elevation of a gable moulding in octagon plan. This problem should be carefully followed, as it presents an interesting study in projections; and the principles used in solving this are also applicable to other problems, no matter what angle or pitch the gable has. By referring to the plan, it will be seen

that the moulding has an octagon angle in plan *a b c*, while similar points in elevation *a′ b′ c′* run on a rake in one line, the top and foot of the moulding butting against the brick piers B and A.

The method of proceeding with work of this kind is explained in detail in Fig 307, where the principles are thoroughly explained. Let A B C D E represent a plan view of the wall, over which a gable moulding is to be placed, as shown by G H I J, the given profile of the

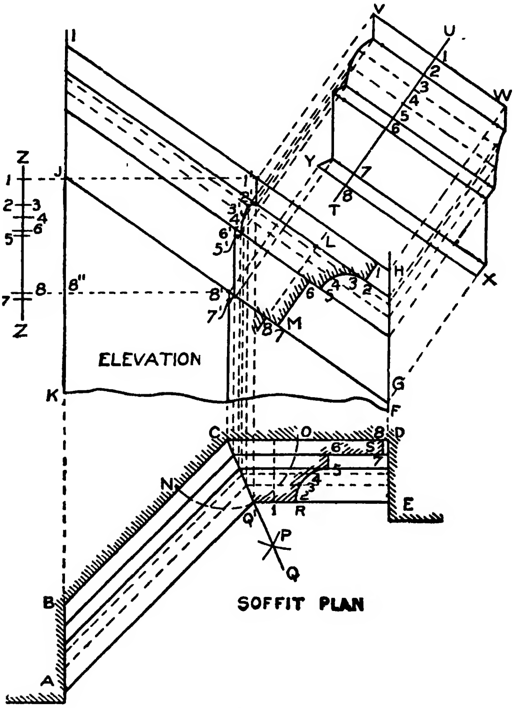


Fig. 307.

moulding being shown by L M. Divide the profile into equal spaces as shown by the figures 1 to 8. Parallel to I H or J G, and through the figures mentioned, draw lines indefinitely as shown. Bisect the angle B C D in plan, and obtain the miter-line as follows: With C as center, and any radius, describe the arc N O. With N and O as centers, and any radius greater than C N or C O, describe arcs intersecting each other at P. From the point C, and through the intersection P, draw the miter-line C Q. Transfer the profile L M in elevation to the posi-

tion shown by R S in plan, dividing it into the same number of spaces as L M. Through the figures in the profile R S, and parallel to D C, draw lines intersecting the miter-line C Q, as shown. From the intersections on the miter-line, and parallel to C B, draw lines intersecting the surface B A. Now, at right angles to C D in plan, and from the

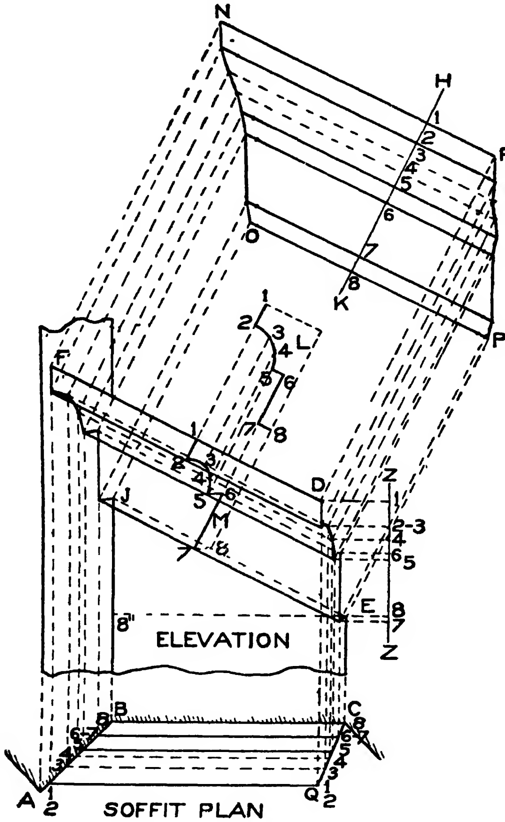


Fig. 308.

intersections on the miter-line C Q, draw vertical lines upward, intersecting lines of similar numbers drawn from points in profile L M in elevation parallel to J G. A line traced through points thus obtained, as shown from 1′ to 8′, will be the miter-line in elevation.

For the pattern for that part of the moulding shown by C D E Q′ in plan, and H G 8′ 1′ in elevation, proceed as follows: At right angles to 1 H in elevation, draw the line T U, upon which place the

stretchout of the profile L M, as shown by the figures 1 to 8. At right angles to T U, and through these figures, draw lines, as shown, which intersect with lines of similar numbers drawn at right angles to 1 H from intersections on the miter-line 1′ 8′ and from intersections against the vertical surface H G. Lines traced through points thus obtained, as shown by V W X Y, will be the pattern for that part of the gable shown in plan by C D E Q′ of Fig. 307.

In Fig. 308, on the other hand, the position of the plan is changed, so as to bring the line A Q horizontal. At right angles to B C draw the vertical line C E, on which locate any point, as E. In the same manner, at right angles to C B, draw the vertical line B J indefinitely. From the point E, parallel to B C, draw the line E 8″, intersecting the line J B, as shown. Now take the distance from 8″ to J in elevation, Fig. 307, and set it off from 8″ toward J in Fig. 308. Draw a line from J to E, which will represent the true rake for this portion of the moulding. Now take the various heights shown from 1 to 8 on the line Z Z in elevation in Fig. 307, and place them as shown by Z Z in elevation, Fig 308, being careful to place the point 8 of the line Z Z on the line 8″ E extended. At right angles to Z Z, and from points on same, draw lines, which intersect with lines drawn at right angles to B C from intersections of similar numbers on C Q in plan. A line traced through points thus obtained, as shown by D E in elevation, will be the miter-line on C Q in plan.

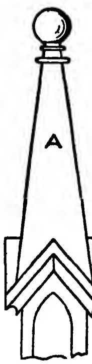


Fig. 309.

From the intersections on the miter-line D E, and parallel to E J, draw lines, which intersect with lines drawn from intersections of similar numbers on A B in plan at right angles to B C. A line traced through points thus obtained, as shown by F J, will be the miter-line or line of joint against the pier shown in plan by B A.

Before obtaining the pattern it will be necessary to obtain a true section or profile at right angles to the moulding F D. To do so, proceed as follows: Transfer the given profile L M in elevation in Fig. 307, with the divisions and figures on same, to a position at right angles to F D of Fig. 308, as shown at L. At right angles to F D, and from the intersections in the profile L, draw lines intersecting those of similar numbers in F D E J. Trace a line through intersections thus ob-

tained, as shown from 1 to 8, thus giving the profile M, or true sections at right angles to F D.

For the pattern, proceed as follows: At right angles to F D, draw the line H K, upon which place the stretchout of the profile M, as shown by the figures. At right angles to H K, and through the figures, draw lines, which intersect with those of similar numbers drawn at

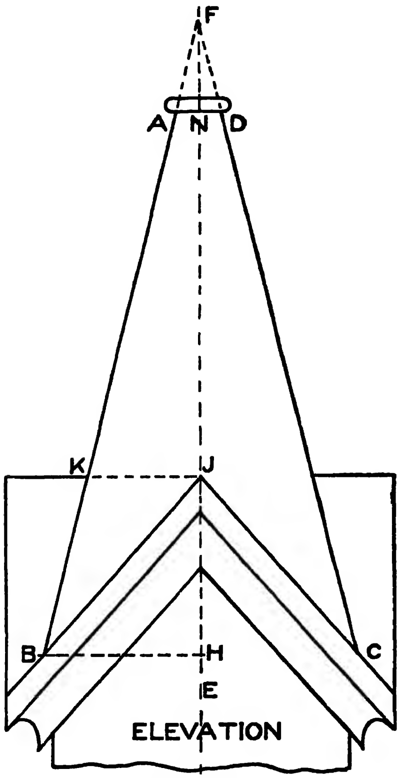


Fig. 310.

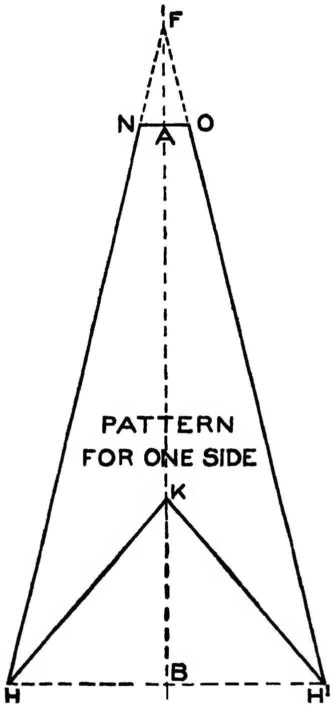


Fig. 311.

right angles to F D from points of intersection in the miter-lines D E and J F, as shown. Lines traced through points thus obtained, as shown by N O P R, will be the pattern for the raking moulding shown in plan, Fig. 307, by A B C Q′.

In Fig. 309 is shown a view of a spire, square in plan, intersecting four gables. In practice, each side A is developed separately in a manner shown in Fig. 310, in which first draw the center line through the center of the gable, as E F. Establish points B and C, from which

DORMER ON MUSÉE DE CLUNY, PARIS, FRANCE

Built in the Fifteenth Century. Note the Figure Sculpture at Sides of Dormer.

draw lines to the apex F. At pleasure, establish A D. At right angles to F E, and from B and J, draw the lines B H and J K respectively. For the pattern, take the distances B K, K A, and A F, and place them as shown by similar letters on the vertical line B F in Fig. 311. At right angles to B F, and through points B and A, draw lines as shown, making B H and B H^1 on the one hand, and A N and A O on the other hand, equal respectively to B H and A N in elevation in Fig. 310. Then, in Fig.

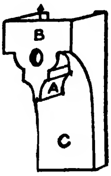


Fig. 312.

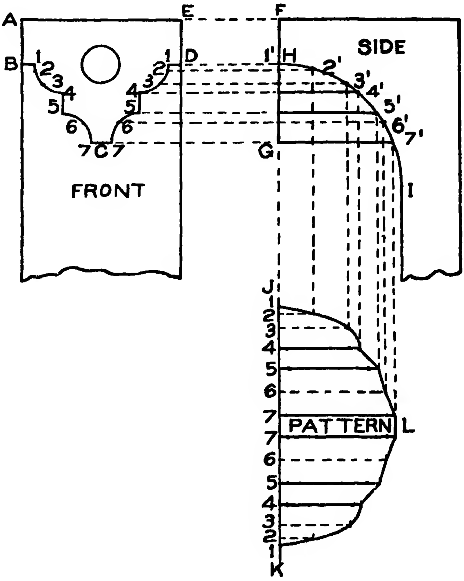


Fig. 313.

311, draw lines from N to H to K to H^1 to O, as shown, which represents the pattern for one side.

In Fig. 312 is shown a perspective view of a drop B mitering against the face of the bracket C as indicated at A. The principles for developing this problem are explained in Fig. 313, and can be applied to similar work no matter what the profiles of the drop or bracket may be. Let A B C D E represent the face or front view of the bracket drop, and F H G I the side of the drop and bracket. Divide one-half of the face, as D C, into equal spaces, as shown by the figures 1 to 7 on either side, from which points draw horizontal lines crossing H G in side view and intersecting the face H I of the bracket at points 1′ to 7′. In line with H G, draw the line J K, upon which place the stretch-out of the profile B C D, as shown by 1 to 7 to 7 to 1 on J K. At right angles to J K, draw the usual measuring lines as shown. which intersect by lines drawn parallel to J K from similarly numbered intersections on H I. Trace a line through the points thus obtained. Then

and 10′ 10″ 15″ 15′ the pattern for the sink strip shown by the lines K L and H J in the front.

For the pattern for the face strip B, draw any line, as A^1 B^1, at right angles to G M, upon which place the stretchout of 10 15 in the normal profile, as shown from 10 to 15 on A^1 B^1. Through these points, at right angles to A^1 B^1, draw lines as shown, which intersect with lines drawn from similar intersections on the lines F G and H J. Trace a line through points thus obtained as shown by F^o G^o H^o J^o, which will be the pattern for the face B, B.

For the pattern for the sink-face C, draw C^1 D^1 at right angles to GM, upon which place the stretchout of 10′ 15′ in the normal profile as shown from 10′ to 15′ on C^1 D^1, through which, at right angles to C^1 D^1, draw lines, which intersect by lines drawn from similar intersections on K L and H J. Trace a line through the points so obtained as J^o K^o L^o H^o, which is the pattern for the sink-face C.

The pattern for the cap D and the face A will be developed in one piece, by drawing at right angles to EO the line E^1 F^1. At right angles

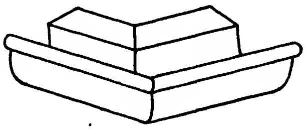


Fig. 316.

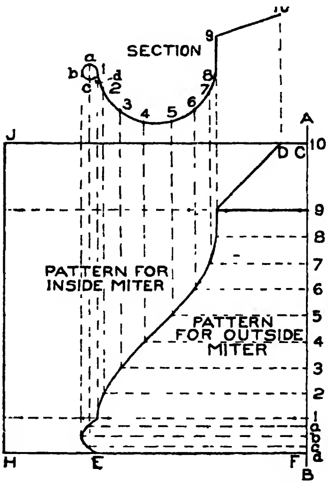


Fig. 317

to E^1 F^1, and through the figures, draw lines, which intersect with lines drawn at right angles to EO from similarly numbered intersections on REF and NOP. A line traced through the points thus obtained, as shown by R^o E^o F^o and N^o O^o P^o will be the pattern for D and A.

For the patterns for the cap returns R E and O P, draw any line at right angles to 1 1 in the normal profile, as H^1 G^1, upon which place the stretchouts of the profiles R E and O P, being careful to carry each space separately onto the line H^1 G^1, as shown respectively by 6^v 1^v and 6^x 1^x. Through these points draw lines at right angles to G^1 H^1, which intersect by lines drawn at right angles to 1 1 from

similar numbers in W and X. Trace lines through the points thus obtained. Then will N^1 O^1 R^1 S^1 be the pattern for the lower return of the cap, R E; while J^1 M^1 L^1 K^1 will be the pattern for the upper return, P O.

In Fig. 316 is shown a perspective view of a gutter or eave-trough at an exterior angle, for which an outside miter would be required. It is immaterial what shape the gutter has, the method of obtaining the pattern for the miter is the same. In Fig. 317 let 1 9 10 represent the section of the eave-trough with a bead or wire edge at *a b c*; divide the wire edge, including the gutter and flange, into an equal number of spaces, as shown by the small divisions *d* to 1 to 9 to 10. Draw any vertical line, as A B, upon which place the stretch-out of the gutter as shown by similar letters and numbers on A B, through which, at right angles to A B, draw lines, which intersect by lines drawn parallel to A B from similar points in the section. Trace a line through the points thus obtained. Then will C D E F be the pattern for the outside angle shown in Fig. 316.

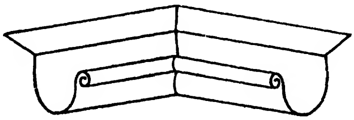


Fig. 318.

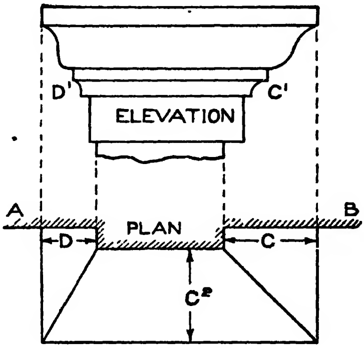


Fig. 319.

If a pattern is required for an interior or inside angle, as is shown in Fig. 318, it is necessary only to extend the lines C D and F E in the pattern in Fig. 317, and draw any vertical line, as J H. Then will J D E H be the pattern for the inside angle shown in Fig. 318.

In Fig. 319 are shown a plan and elevation of a moulding which has more projection on the front than on the side. In other words, A B represents the plan of a brick pier, around which a cornice is to be constructed. The projection of the given profile is equal to C, the profile in elevation being shown by C^1. The projection of the front in plan is also equal to C, as shown by C^2. The projection of the left side of the cornice should be only as much as is shown by D in plan. This requires a change of profile through D, as shown by D^1. To ob-

tain this true profile and the various patterns, proceed as shown in Fig. 320, in which A B C D represents the plan view of the wall, against which, in its proper position, the profile E is placed and divided into equal spaces, as shown by the figures 1 to 12. Through 1 2, parallel to C D, draw G F. Locate at pleasure the projection of the re-

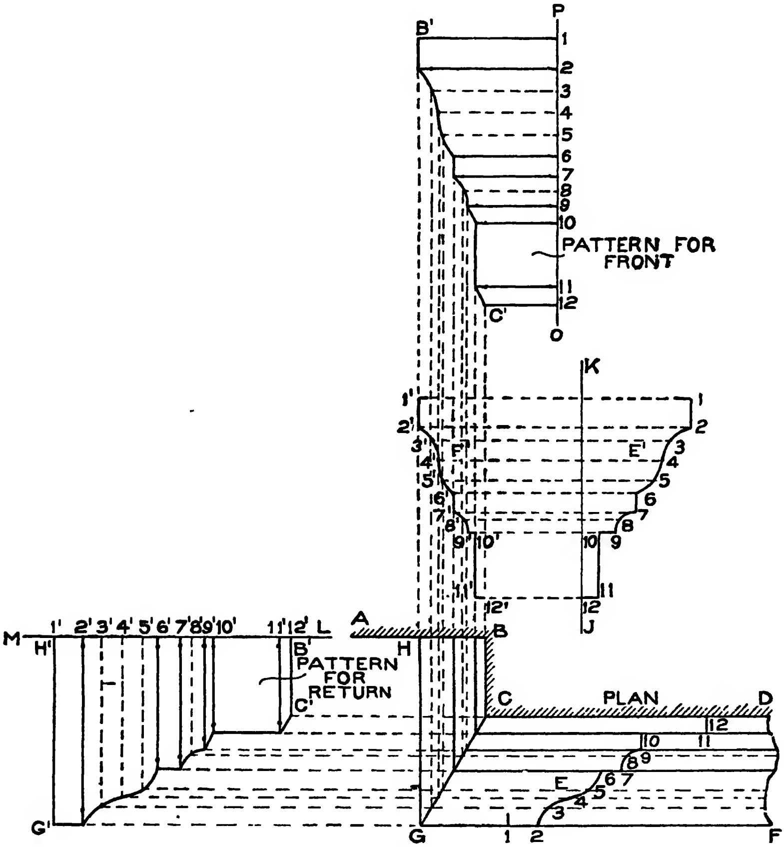


Fig. 320.

turn mould, as B H, and draw H G parallel to B C, intersecting F G at G. Draw the miter-line in plan, G C. From the various divisions in the profile E, draw lines parallel to C D, intersecting the miter-line C G as shown. From these intersections, erect vertical lines indefinitely, as shown. Parallel to these lines erect the line K J, upon which place a duplicate of the profile E, with the various divisions on same, as shown by E^1. Through these divisions draw horizontal lines in-

tersecting the similarly numbered vertical lines, as shown by the intersections 1′ to 12′. Trace a line through these points. Then will F^1 be the true section or profile on H B in plan.

For the pattern for the return H G C B in plan, extend the line B A, as B M, upon which place the stretchout of the profile F^1, being careful to measure each space separately (as they are unequal), as shown by figures 1′ to 12′ on M B.

At right angles to this line and through the figures, draw lines, which intersect by lines drawn at right angles to H G from similar points on C G. Trace a line through the points thus obtained. Then will H^1 G^1 C^1 B^1 be the pattern for the return mould.

The pattern for the face mould G C D F is obtained by taking a stretchout of the profile E and placing it on the vertical line P O, as shown by similar figures, through which, at right angles to P O, draw lines intersecting similarly numbered lines previously extended from C G in plan. Trace a line through these intersections. Then will 1 B^1 C^1 12 be the miter pattern for the face mould.

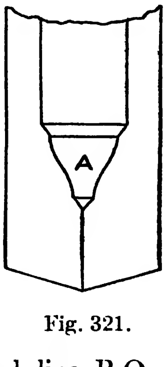


Fig. 321.

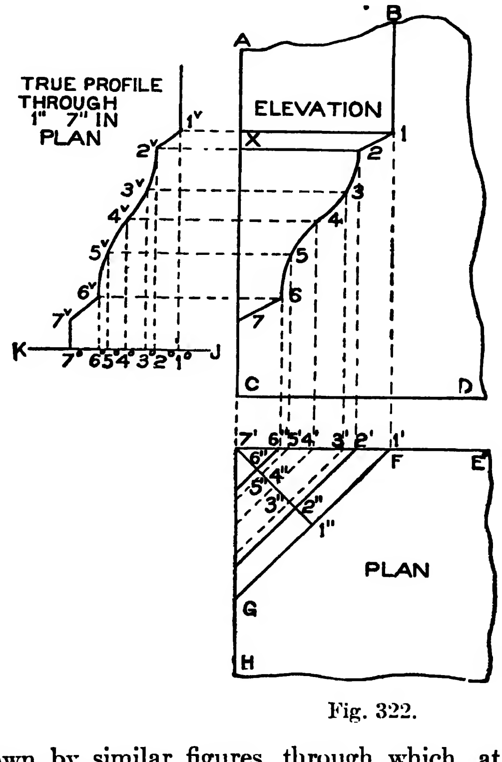


Fig. 322.

In Fig. 321 is shown a perspective view of a gore piece A joined to a chamfer. This presents a problem often arising in ornamental

sheet-metal work, the development of which is given in Fig. 322. Let A B C D show the elevation of the corner on which a gore piece is required. H 7′ E in plan is a section through C D, and E F G H is a section through X I, all projected from the elevation as shown. The profile 1 7 can be drawn at pleasure, and at once becomes the pattern for the sides. Now divide the profile 1 7 into an equal number of spaces as shown, from which drop vertical lines onto the side 7′ E in plan, as shown from 1′ to 7′. From these points draw lines parallel to F G, intersecting the opposite side and crossing the line 7′ 1″ (which is drawn at right angles to F G from 7′) at 1″ 2″ 3″ 4″ 5″ 6″. Draw any line parallel to C D, as K J, upon which place all the intersections contained on 7′ 1″ in plan, as shown by 1° to 7° on K J. From these points erect perpendicular lines, which intersect by lines drawn from similarly numbered points in elevation parallel to C D. Through the points thus obtained trace a line. Then will 1^v to 7^v be the true profile on 7′ 1″ in plan.

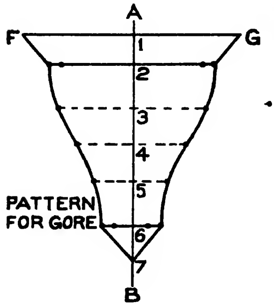


Fig. 323.

For the pattern for the gore, draw any vertical line, as A B in Fig 323, upon which place the stretchout of the profile 1^v 7^v in Fig. 322, as shown by similar figures on A B in Fig. 323. At right angles to AB, and through the figures, draw lines as shown, Now, measuring in each instance from the line 7′ 1″ in plan in Fig. 322, take the various distances to points 1′ to 7′, and place them in Fig. 323 on similarly numbered lines, measuring in each instance from the line A B, thus locating the points shown. Trace a line through the points thus obtained. Then will F G 7 be the pattern for the gore shown in plan in Fig. 322 by F G 7′.

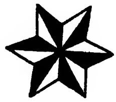


Fig. 324.

In Fig. 324 is shown a face view of a six-pointed star, which often arises in cornice work. No matter how many points the star has, the principles which are explained for its development are applicable to any size or shape. Triangulation is employed in this problem, as shown in Fig. 325. First draw the half-outline of the star, as shown by A B C D E F G. Above and parallel to the line AG, draw JH of similar length, as shown. Draw the section of the star on A G in plan,

as shown by J K H. Project K into plan as shown at I, and draw the miter-lines B I, C I, D I, E I, and F I. As K H is the true length on I G, it is necessary that we find the true length on I F. Using I F as radius and I as center, draw an arc intersecting I G at *a*. From *a* erect a line cutting J H in section at *b*. Draw a line from *b* to K, which is the true length on I F.

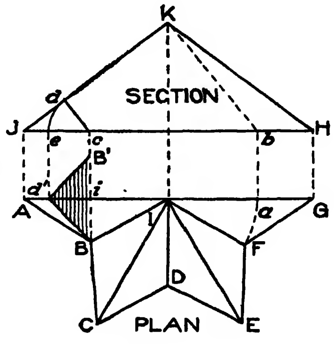


Fig. 325.

For the pattern, proceed as shown in Fig. 326. Draw any line, as K H, equal in length to K H in Fig. 325. Then, using K *b* as radius and K in Fig. 326 as center, describe the arc *b b*, which intersect at *a* and *a* by an arc G G struck from H as center and with F G in plan in Fig. 325 as radius. Draw lines in Fig. 326 from K to *a* to H to *a* to K, which will be the pattern for one of the points of the star of which 6 are required.

When bending the points on the line HK, it is necessary to have a stay or profile so that we may know at what angle the bend should be made. To obtain this stay, erect from the corner B in Fig. 325 a line intersecting the base-line J H at *c*, from which point, at right angles to J K, draw *c d*. Using *c* as center, and *c d* as radius, strike an arc intersecting J H at *e*. From *e* drop a vertical line meeting A G in plan at *d'*. Set off *i* B[1] equal to *i* B, and draw a line from B to *d'* to B[1], which is the true profile after which the pattern in Fig. 326 is to be bent. If the stay in Fig. 325 has been correctly developed, then *d'* B[1] or *d'* B must equal *c a* in Fig. 326 on both sides.

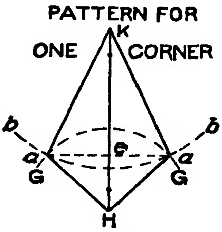


Fig. 326.

In Fig. 327 is shown a finished elevation of a hipped roof, on the four corners of which a hip ridge A A butts against the upper base B and cuts off on a vertical line at the bottom, as C and C. To obtain the true profile of this hip ridge, together with the top and lower cuts and the patterns for the lower heads, proceed as shown in Fig. 328, where the front elevation has been omitted, this not being necessary, as only the part plan and diagonal elevation are required. First draw

the part plan as shown by A B C D E F A, placing the hip or diagonal line F C in a horizontal position; and make the distances between the lines F A and C B and between F E and C D equal, because the roof in this case has equal pitch all around. (The same principles, however, would be used if the roofs had unequal pitches.) Above the plan, draw the line G H. From the points F and C in plan, erect the lines F G and C I, extending C I to C^1 so that I C^1 will be the required height of the roof above G I at the point C in plan. Draw a line from G to C^1, and from C^1 draw a horizontal and vertical line indefinitely, as shown. Then will I G C^1 be a true section on the line of the roof on F C in plan.

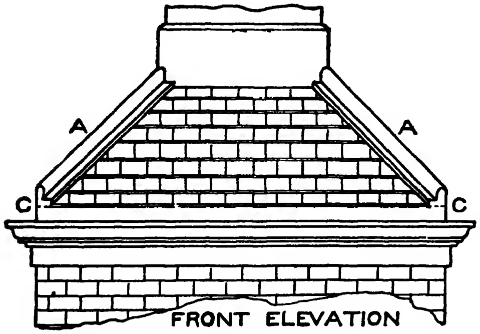


Fig. 327.

The next step is to obtain a true section of the angle of the roof at right angles to the hip line G C^1 in elevation. This is done by drawing at right angles to F C in plan, any line, as *a b*, intersecting the lines F A and F E as shown. Extend *a b* until it cuts the base-line G I in elevation at *c*. From *c*, at right angles to G C^1, draw a line, as *c d*, intersecting G C^1 at *d*. Take the distance *c d*, and place it in plan on the line F C, measuring from *i* to *d'*. Draw a line from *a* to *d'* to *b*, which is the true angle desired. On this angle, construct the desired shape of the hip ridge as shown by J, each half of which divide into equal spaces, as shown by the figures 1 to 6 to 1. As the line G C^1 represents the line of the roof, and as the point *d'* in plan in the true angle also represents that line, then take a tracing of the profile J with the various points of intersection on same, together with the true angle *a d' b*, and place it in the elevation as shown by J^1 and *a' d'' b'*, being careful to place the point *d''* on the line G C^1, making *a' b'* parallel to G C^1. From the various points of intersection in the profile J, draw lines parallel to F C, intersecting B C and A F at points from 1 to 6, as shown. As both sides of the profile J are symmetrical, it is necessary only to draw lines through one-half.

In similar manner, in elevation, parallel to G C¹, draw lines through the various intersections in J¹, which intersect by lines drawn at right angles to F C in plan from similarly numbered points on A F

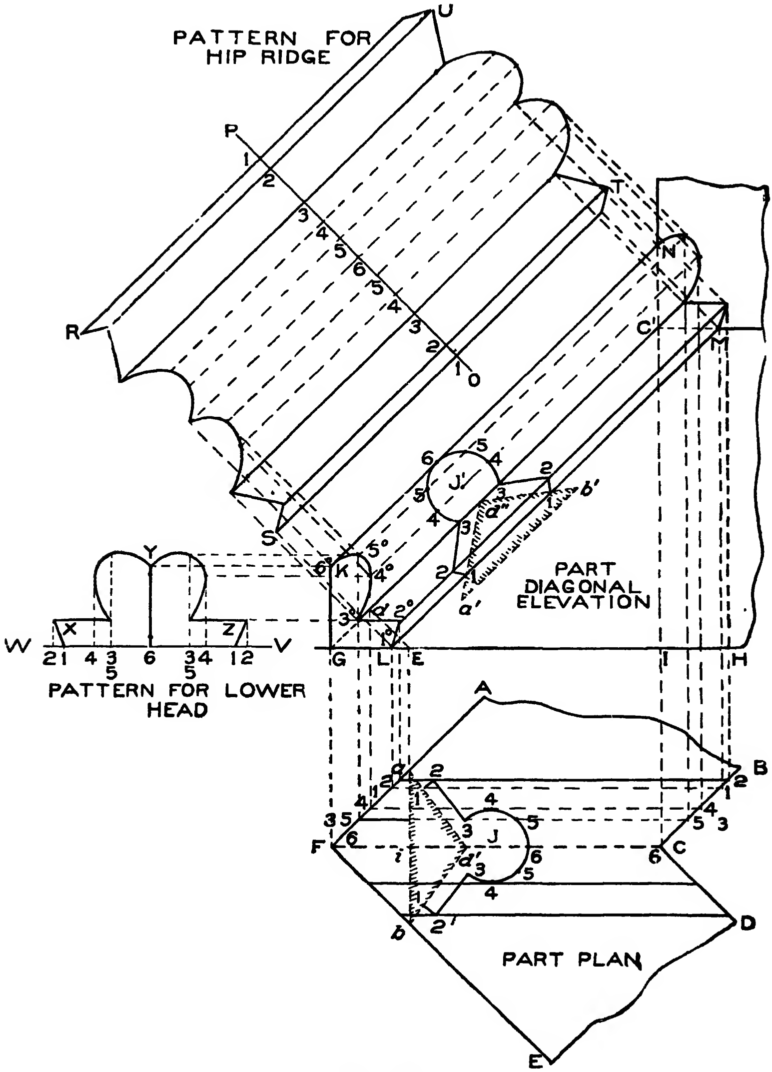


Fig. 328.

and BC. Trace a line through the points thus obtained. Then will K L be the miter-line at the bottom, and M N the miter-line at the top.

For the pattern, draw any line, as O P, at right angles to G C¹,

upon which place the stretchout of J in plan or J^1 in elevation, as shown by the figures 1 to 6 to 1 on O P; and through these numbered points, at right angles to O P, draw lines, which intersect by lines drawn at right angles to G C^1 from similar intersections in the lower miter-line K L and upper miter-line N M. Trace a line through the points thus obtained. Then will R S T U be the desired pattern.

In practice it is necessary only to obtain one miter-cut—either the top or the bottom—and use the reverse for the opposite side. In other words, U T is that part falling out of R S, the same as R S is that part which cuts away from U T. The upper miter-cut butts against B in Fig. 327; while the lower cut requires a flat head, as shown at C. To obtain this flat head, extend the line I G in Fig. 328, as I W, upon which place twice the amount of spaces contained on the line A F in plan, as 6, 3–5, 4, 1, 2, as shown by similar figures on either side of 6 on the line V W. From these divisions erect vertical lines, which intersect by lines drawn parallel to V W from similarly numbered intersections in the miter-line K L G. A line traced through the points thus obtained, as shown by X Y Z, will be the pattern for the heads.

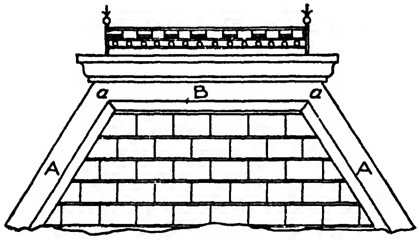


Fig. 329.

Where a hip ridge is required to miter with the apron of a deck moulding, as shown in Fig. 329, in which B represents the apron of the deck cornice, A and A the hip ridges mitering at *a* and *a*, a slightly different process from that described in the preceding problem is used. In this case the part elevation of the mansard roof must first be drawn as shown in Fig. 330. Let A B C K represent the part elevation of the mansard, the section of the deck moulding and apron being shown by D B E. Draw E X parallel to B C. E X then represents the line of the roof. In its proper position, at right angles to B C, draw a half-section of the hip mould, as shown by F G, which is an exact reproduction of B E of the deck mould Through the corners of the hip mould at Y and G, draw lines parallel to B C, which intersect by lines drawn parallel to B A from V, W, and E in the deck cornice. Draw the miter-line H I, which completes the part elevation of the mansard.

Before the patterns can be obtained, a developed surface of the mansard must be drawn. Therefore, from B (Fig. 330), drop a vertical line, as B J, intersecting the line C K at J. Now take the distance of B C, and place it on a vertical line in Fig. 331, as shown by B C^1. Through these two points draw the horizontal lines B A and C K as shown. Take the projection J to C in Fig. 330, and place it as

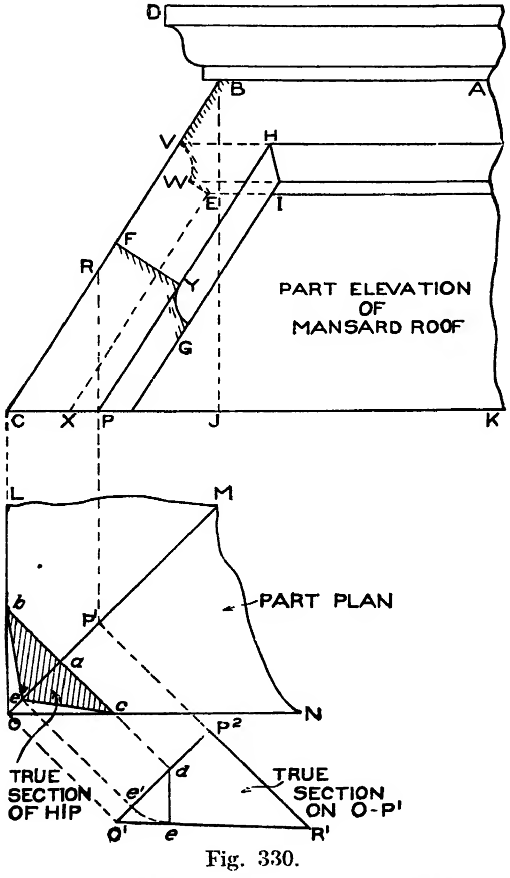


Fig. 330.

shown from C^1 to C in Fig. 331, and draw a line from C to B. Then will A B C K be the developed surface of A B C K in Fig. 330.

As both the profiles B V W E and F Y G are similar, take a tracing of either, and place it as shown by D and D^1 respectively in Fig. 331. Divide both into the same number of equal spaces, as shown. Bisect the angle A B C by establishing *a* and *b*, and, using these as centers,

by describing arcs intersecting at c; then draw d B, which represents the miter-line. Through the points in D and D^1, draw lines parallel to their respective moulds, as shown, intersecting the miter-line B d and the base-line C C^1.

For the pattern for the hip, draw any line, as E F, at right angles to B C, upon which place twice the stretchout of D, as shown by the divisions 6 to 1 to 6 on EF. Through these divisions draw lines at

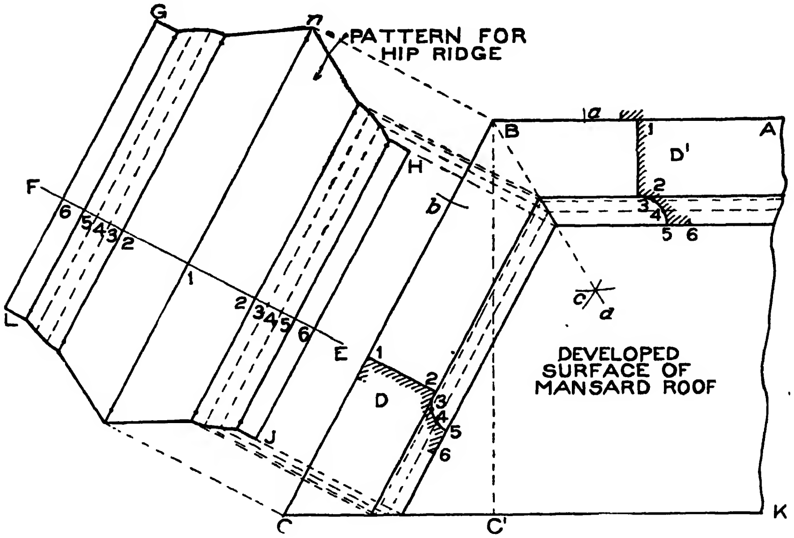


Fig. 331.

right angles to E F, intersecting similarly numbered lines drawn at right angles to B C from the divisions on B d and C C^1. Trace a line through the points thus obtained. Then will G H J L be the pattern for the hip ridge.

When bending this ridge in the machine, it is necessary to know at what angle the line 1 in the pattern will be bent. A true section must be obtained at right angles to the line of hip, for which proceed as shown in Fig. 330. Directly in line with the elevation, construct a part plan L M N O, through which, at an angle of 45 degrees (because the angle L O N is a right angle), draw the hip line O M. Establish at pleasure any point, as P^1 on O M, from which erect the vertical line into the elevation crossing the base-line C K at P and the ridge-line C B at R. Parallel to O M in plan, draw O^1 P^2, equal to O P^1, as shown. Extend P^1 P^2 as P^2 R^1, which make equal to PR in elevation.

Draw a line from R^1 to O^1. Then $O^1 R^1 P^2$ represents a true section on OP^1 in plan. Through any point, as *a*, at right angles to OM, draw *bc*, cutting L O and ON at *b* and *c* respectively. Extend *b c* until it intersects $O^1 P^2$ at *d*. From *d*, at right angles to $O^1 R^1$, draw the line *d e*. With *d* as center, and *de* as radius, draw the arc *e e'*, intersecting $O^1 P^2$ at *e'*, from which point, at right angles to OM in plan, draw a line intersecting OM at *e''*. Draw a line from *b* to *e''* to *c*, which represents the true section of the hip after which the pattern shown in Fig. 331 is formed.

The pattern for the deck mould D B in Fig. 330 is obtained in the same way as the square miter shown in Fig. 277; while the pattern for the apron D^1 in Fig. 331 is the same as the one-half pattern of the hip ridge shown by *n* H 1 6.

In Fig. 332 is shown a front elevation of an eye-brow dormer. In this view A B C represents the front view of the dormer, the arcs being

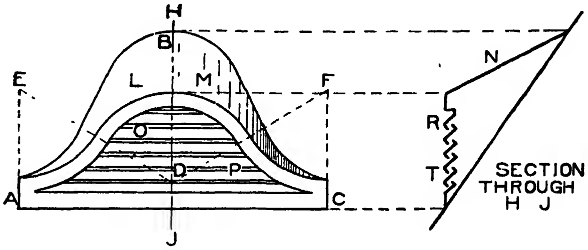


Fig. 332.

struck from the center points D, E, and F. A section taken on the line H J in elevation is shown at the right; L M shows the roof of the dormer, indicated in the section by N; while the louvers are shown in elevation by O P and in section by RT.

In Fig. 333 is shown how to obtain the various patterns for the various parts of the dormer. ABC represents the half-elevation of the dormer, and EFG a side view, of which EG is the line of the dormer, EF that of the roof, and GF the line of the pitched roof against which the dormer is required to miter.

The front and side views being placed in their proper relative positions, the first step is to obtain a true section at right angles to EF. Proceed as follows: Divide the curve A to B into a number of equal spaces, as shown from 1 to 9. At right angles to A C, and from the figures on A B, draw lines intersecting E G in side view as shown.

From these intersections, and parallel to EF, draw lines intersecting the roof-line GF at 1^5, 2^5, 3^5, etc. Parallel to EF, and from the point

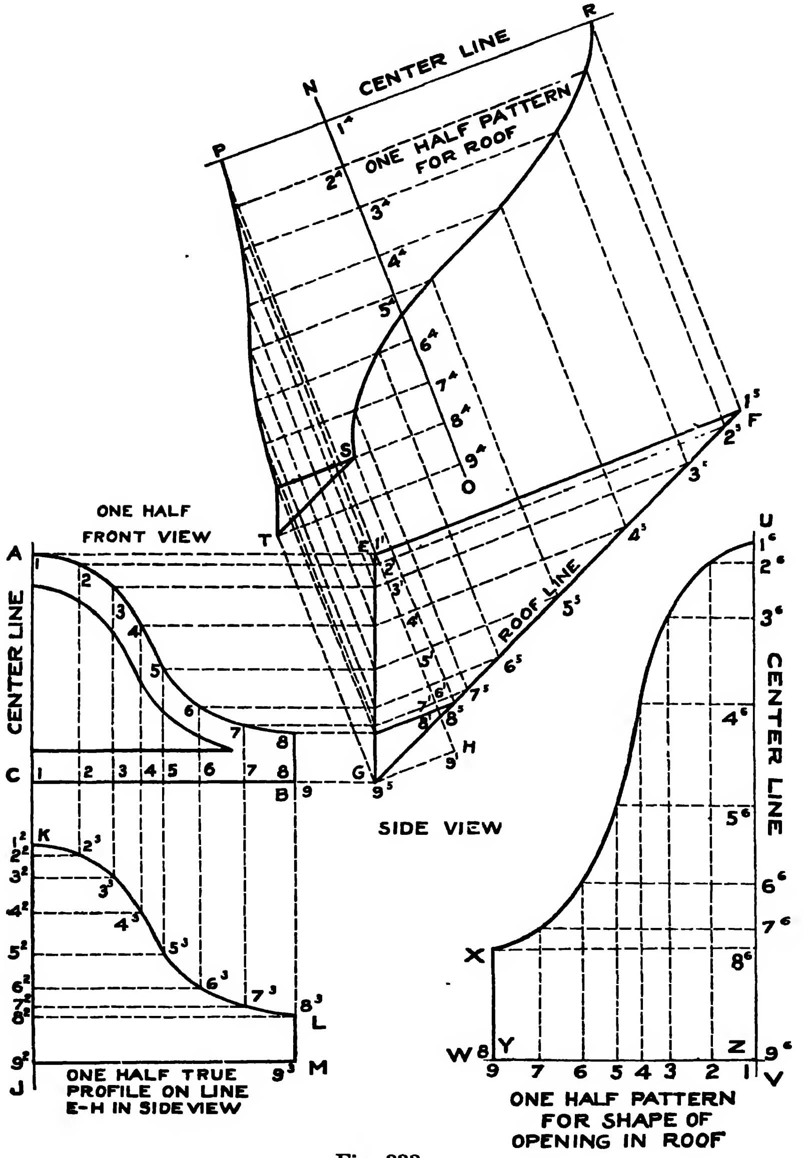


Fig. 333.

G, draw any line indefinitely, as G H. At right angles to EF, and from the point E, draw the line EH, intersecting lines previously drawn,

at 1^1, 2^1, 3^1, etc., as shown. Now take a duplicate of the line E H, with the various intersections thereon, and place it on the center line AC extended as KJ. At right angles to KJ, and from the figures 1^2, 2^2, 3^2, etc., draw lines, which intersect with those of similar numbers drawn at right angles to CB, and from similarly numbered points on the curve A B. Trace a line through the points of intersection thus obtained. Then KLMJ will be one-half the true profile on the line E H in side view, from which the stretchout will be obtained in the development of the pattern.

For the pattern for the roof of the dormer, draw at right angles to EF in side view the line N O, upon which place the stretchout of one-half the true profile on the line EH as shown by the small figures 1^4, 2^4, 3^4, etc. Then, at right angles to N O, and through the figures, draw lines, which intersect with those of similar numbers drawn at right angles to EF from intersections on EG and GF. Trace a line through the points thus obtained. Then will PRST represent one-half the pattern for the roof.

To obtain the pattern for the shape of the opening to be cut into the roof, transfer the line GF, with the various intersections thereon, to any vertical line, as UV, as shown by the figures 1^6. 2^6, 3^6, etc. In similar manner, transfer the line CB in front view, with the various intersections on same, to the line ZW, drawn at right angles to UV, as shown by the figures 1, 2, 3, etc. At right angles to UV, and from the figures, draw lines, which intersect with those of similar numbers drawn at right angles to YZ. Through these points, trace a line. Then will UXYZ be the half-pattern for the shape of the opening to be cut into the main roof.

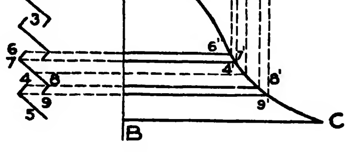


Fig. 334.

For the pattern for the ventilating slats or louvers, should they be required in the dormer, proceed as shown in Fig. 334. In this figure, A B C is a reproduction of the inside opening shown in Fig. 333. Let 1, 2, 3, 4, 5 in Fig. 334 represent the sections of the louvers which will be placed in this opening. As the methods of obtaining the pat-

terns for all louvers are alike, the pattern for louver No. 4 will illustrate the principles employed. Number the various bends of louver No. 4 as shown by points 6, 7, 8, and 9. At right angles to A B, and from these points, draw lines intersecting the curve A C as 6^1, 7^1, 4^1, 8^1, and 9^1. On B A extended as E D, place the stretchout of louver No. 4 as shown by the figures on ED. Since the miter-line AC is a curve, it will be necessary to introduce intermediate points between 7 and 8 of the profile, in order to obtain this curve in the pattern. In this instance the point marked 4 has been added.

Now, at right angles to DE, and through the figures, draw lines, which intersect with those of similar numbers, drawn parallel to AB from intersections 6^1 to 9^1 on the curve AC. A line traced through the points thus obtained, as FKJH, will be the half-pattern for louver No. 4. The pattern for the face of the dormer is pricked onto the metal direct from the front view in Fig. 333, in which A 8 B C is the half-pattern.

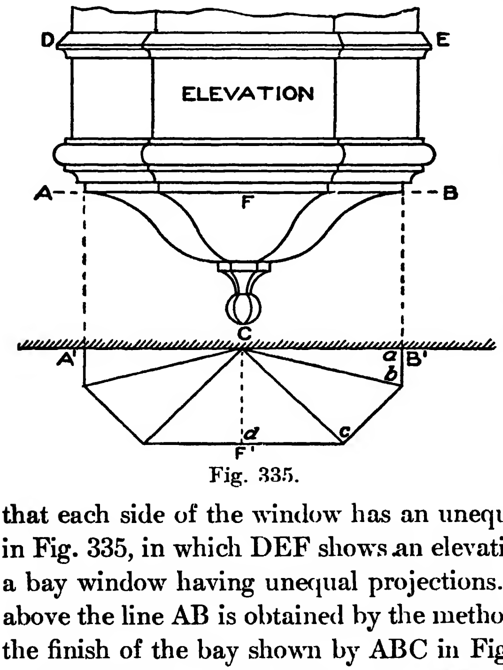


Fig. 335.

In laying out the patterns for bay window work, it often happens that each side of the window has an unequal projection, as is shown in Fig. 335, in which DEF shows an elevation of an octagonal base of a bay window having unequal projections. All that part of the bay above the line AB is obtained by the method shown in Fig. 290, while the finish of the bay shown by ABC in Fig. 335 will be treated here. In some cases the lower ball C is a half-spun ball. A^1 B^1 F^1 is a true section through A B. It will be noticed that the lines C*a*, C*c*, and C*d*, drawn respectively at right angles to *ab*, *bc*, and *cd*, are each of different lengths, thereby making it necessary to obtain a true profile on each of these lines, before the patterns can be obtained. This is clearly explained in connection with Fig. 336, in which only a half-elevation and plan are required as both sides are symmetrical. First draw the

center line AB, on which draw the half-elevation of the base of the bay, as shown by CDE. At right angles to AB draw the wall line in plan, as FK; and in its proper position in relation to the line CD in elevation, draw the desired half-plan, as shown by GHIJ. From the corners H and I draw the miter-lines HF and IF, as shown. As DE

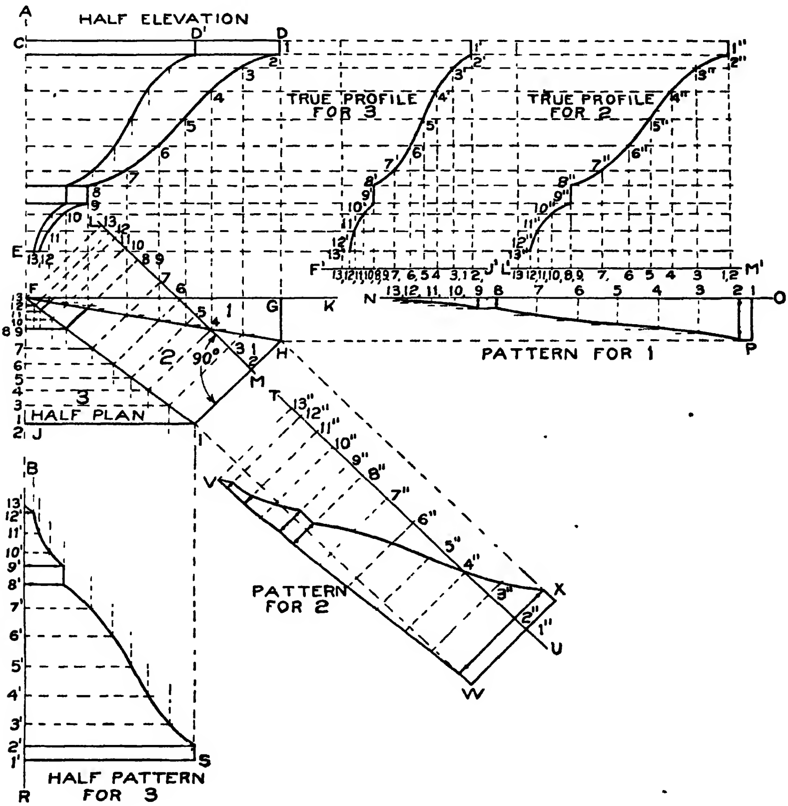


Fig. 336.

represents the given profile through FG in plan, then divide the profile DE into an equal number of spaces as shown by the figures 1 to 13. From these points drop vertical lines intersecting the miter-line FH in plan, as shown. From these intersections, parallel to HI, draw lines intersecting the miter-lines IF, from which points, parallel to IJ, draw lines intersecting the center line FB. Through the various points of intersection in DE, draw horizontal lines indefinitely right and left as shown.

If for any reason it is desired to show the elevation of the miter-line FI in plan (it not being necessary in the development of the pattern), then erect vertical lines from the various intersections on FI, intersecting similar lines in elevation. To avoid a confusion in the drawing, these lines have not been shown. Trace a line through points thus obtained, as shown by D^1 13, which is the desired miter-line in elevation.

The next step is to obtain the true profile at right angles to HI and IJ in plan. To obtain the true profile through No. 3 in plan, take a tracing of J F, with the various intersections thereon, and place it on a line drawn parallel to CD in elevation, as J^1 F^1, with the intersections 1 to 13, as shown. From these intersections, at right angles to J^1 F^1, erect lines intersecting similar lines drawn through the profile DE in elevation. Trace a line through the points thus obtained, as shown by 1′ to 13′, which represents the true profile for part 3 in plan. At right angles to IH in plan, draw any line, as ML, and extend the various lines drawn parallel to IH until they intersect LM at points 1 to 13, as shown.

Take a tracing of LM, with the various points of intersection, and place it on any horizontal line, as L^1 M^1, as shown by the figures 1 to 13, from which, at right angles to L^1 M^1, erect vertical lines intersecting similarly numbered horizontal lines drawn through the profile DE. Trace a line through the points thus obtained. Then will 1″ – 13″ be the true profile through No. 2 in plan at right angles to HI.

For the pattern for No. 1 in plan, extend the line FK, as NO, upon which place the stretchout of the profile DE as shown by the figures 1 to 13 on NO. At right angles to NO, and from the figures, draw lines, which intersect with lines (partly shown) drawn parallel to FG from similar intersections on the miter-line FH. Trace a line through the points thus obtained; then will 1 P 13 be the pattern for part 1 in plan.

At right angles to H I, draw any line, as T U, upon which place the stretchout of profile No. 2, being careful to measure each space separately, as they are all unequal, as shown by the small figures 1″ to 13″ on TU. Through these figures, at right angles to TU, draw lines as shown, which intersect by lines (not shown in the drawing) drawn at right angles to I H from similar points on the miter-lines HF and FI.

Trace a line through the points thus obtained. Then will V W X be the pattern for part 2 in plan.

For the half-pattern for part 3 in plan, extend the center line A B in plan as B R, upon which place the stretchout of the true profile for 3, being careful to measure each space separately, as shown by the figures 1′ to 13′ on BR. At right angles to B R draw lines through the figures, which intersect by lines drawn at right angles to J I from similar points of intersection on the miter-line F I. A line traced through points thus obtained, as 1′ S 13′, will be the half-pattern for part 3.

DEVELOPMENT OF BLANKS FOR CURVED MOULDINGS

Our first attention will be given to the methods of construction, it being necessary that we know the methods of construction before the blank can be laid out. For example, in Fig. 337 is a part elevation of a dormer window, with a semicircular top whose profile has an ogee, fillet, and cove. If this job were undertaken by a firm who had no circular moulding machine, as is the case in many of the smaller shops, the mould would have to be made by hand. The method of construction in this case would then be as shown in Fig. 338, which shows an enlarged section through *a b* in Fig. 337. Thus the strips *a*, *b*, and *c* in Fig. 338 would be cut to the required size, and would be nothing more than straight strips of metal, while *d d′* would be an angle, the lower side *d′* being notched with the shears and turned to the required circle. The face strips *e*, *f*, and *h* would represent arcs of circles to correspond to their various diameters obtained from the full-sized elevation. These face and sink strips would all be soldered together, and form a succession of square angles, as shown, in which the ogee, as shown by *i j*, and the cove, as shown by *m*, would be fitted. In obtaining the patterns for the blanks hammered by hand, the averaged lines would be drawn as shown by *k l* for the ogee and *n o* for the cove. The method or principles of averaging these and other moulds will be explained as we proceed.

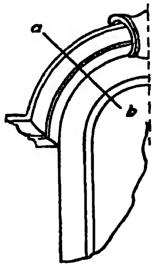


Fig. 337.

In Fig. 339 is shown the same mould as in the previous figure, a different method of construction being employed from the one made by hand and the one hammered up by machine. In machine work this

mould can be hammered in one piece, 8 feet long or of the length of the sheets in use, if such length is required, the machine taking in the full

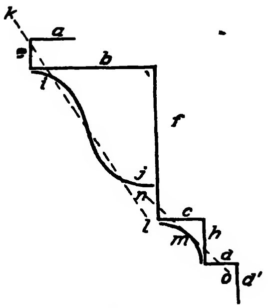


Fig. 338.

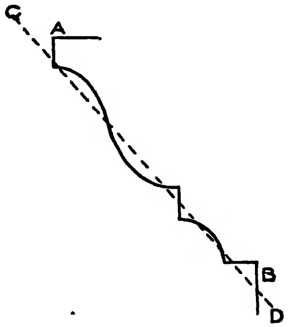


Fig. 339.

mould from A to B. The pattern for work of this kind is averaged by drawing a line as shown by CD. This method will also be explained more fully as we proceed.

SHOP TOOLS EMPLOYED

When working any circular mould by hand, all that is required in the way of tools is various-sized raising and stretching hammers, square stake, blow-horn stake, and mandrel including raising blocks made of wood or lead. A first-rate knowledge must be employed by the mechanic in the handling and working of these small tools. In a thoroughly up-to-date shop will be found what are known as "curved moulding" machines, which can be operated by foot or power, and which have the advantage over hand operation of saving time and labor, and also turning out first-class work, as all seams are avoided.

PRINCIPLES EMPLOYED FOR OBTAINING APPROXIMATE BLANKS FOR CURVED MOULDINGS HAMMERED BY HAND

The governing principles underlying all such operations are the same as every sheet-metal worker uses in the laying out of the simple patterns in flaring ware. In other words, one who understands how to lay out the pattern for a frustum of a cone understands the principles of developing the blanks for curved mouldings. The principles will be described in detail in what follows.

Our first problem is that of obtaining a blank for a plain flare, shown in Fig. 340. First draw the center line A B, and construct the half-elevation of the mould, as C D E F. Extend D E until it inter-

sects the center line A B at G. At right angles to A B from any point, as H, draw H 1 equal to C D, as shown. Using H as center, and with H 1 as radius, describe the quarter-circle 1 7, which is a section on C D. Divide 1 7 into equal spaces, as shown. Now using G as center, with radii equal to G E and G D, describe the arcs D 7′ and E E°. From any point, as 1′, draw the radial line 1′ G, intersecting the inner arc at E^x. Take a stretchout of the quarter-section; place it as shown

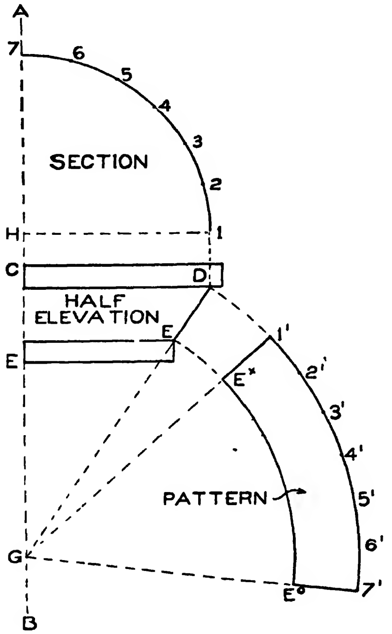


Fig. 310.

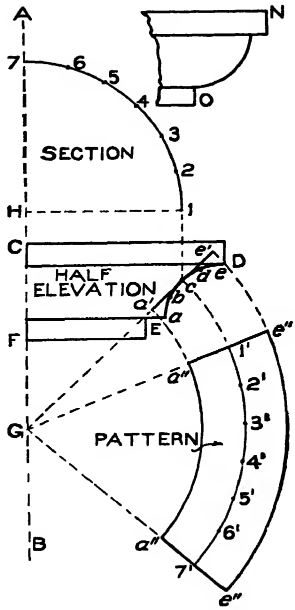


Fig. 341.

from 1′ to 7′; and draw a line from 7′ to G, intersecting the inner arc at E°. Then will E^x 1′ 7′ E° be the quarter-pattern for the flare D E in elevation. If the pattern is required in two halves, join two pieces; if required in one piece, join four pieces.

In Fig. 341 is shown a curved mould whose profile contains a cove. To work this profile, the blank must be stretched with the stretching hammer. *We mention this here so that the student will pay attention to the rule for obtaining patterns for stretched moulds.* First draw the center line A B; also the half-elevation of the moulding, as C D E F. Divide the cove E D into an equal number of spaces, as shown from

a to *e*. Through the center of the cove *c* draw a line parallel to *e a*, extending it until it meets the center line A B at G, which is the center point from which to strike the pattern. Take the stretchout of the cove *c e* and *c a*, and place it as shown by *c e′* and *c a′*. When stretching the flare *a′ e′*, *c* remains stationary, *e′* and *a′* being hammered towards *e* and *a* respectively. Therefore, from *c* erect a vertical line intersecting H 1, drawn at right angles to A B, at 1. Using H as center and H 1 as radius, describe the arc 1 7, which divide into equal spaces as shown. With G as center, and radii equal to G *a′*, G*c*, and G *e′*, describe the arcs *e″ e″*, 1′ 7′, and *a″ a″*. Draw a line from *e″* to G, intersecting the center and lower arcs at 1′ and *a″*. Starting from 1′, lay off the stretchout of the quarter-section as shown from 1′ to 7′. Through 7′ draw a line towards G, intersecting the inner arc at *a″*; and, extending the line upward, intersect the outer arc at *e″*. Then will *a″ e″ e″ a″* be the quarter-pattern for the cove E D in elevation.

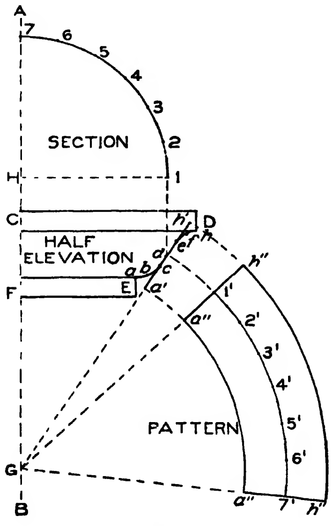


Fig. 342.

If the quarter-round N O were required in place of the cove E D, then, as this quarter-round would require to be raised, the rule given in the former Instruction Paper on Sheet Metal Work would be applied to all cases of raised mouldings.

In Fig. 342 is shown a curved mould whose profile is an ogee. In this case as in the preceding, draw the center line and half-elevation, and divide the ogee into a number of equal parts, as shown from *a* to *h*. Through the flaring portion of the ogee, as *c e*, draw a line, extending it upward and downward until it intersects the center line A B at G. Take the stretchouts from *a* to *c* and from *e* to *h* and place them respectively from *c* to *a′* and from *e* to *h′* on the line *h′* G. Then, in working the ogee, that portion of the flare from *c* to *e* remains stationary; the part from *e* to *h′* will be stretched to form *e h*; while that part shown from *c* to *a′* will be raised to form *c a*. From any point in the stationary flare, as *d*, erect a line meeting the line H 1, drawn at right

angles to A B, at 1. Using H as center and H 1 as radius, describe the quarter-section, and divide same into equal spaces, as shown. With G as center and with radii equal to G a', G d, and G h', describe the arcs a'' a'', $1'$ $7'$, and h'' h''. From h'' draw a line to G. Starting at $1'$, lay off the stretchout of the section as shown from $1'$ to $7'$. Through $7'$ draw a line to G, as before described. Then will h'' a'' a'' h'' be the quarter-pattern for the ogee E D.

In Fig. 343 is shown how the blanks are developed when a bead moulding is employed. As before, first draw the center line A^1 B^1 and the half-elevation A B C D. As the bead takes up $\frac{3}{4}$ of a circle, as shown by *a c e f*, and as the pattern for *f e* will be the same as for *e c*, then will the pattern for *c e* only be shown, which can also be used for *c f*. Bisect *a c* and *c e*, obtaining the points *b* and *d*, which represent the stationary points in the patterns. Take the stretchouts of *b* to *a* and *b* to *c*, and place them

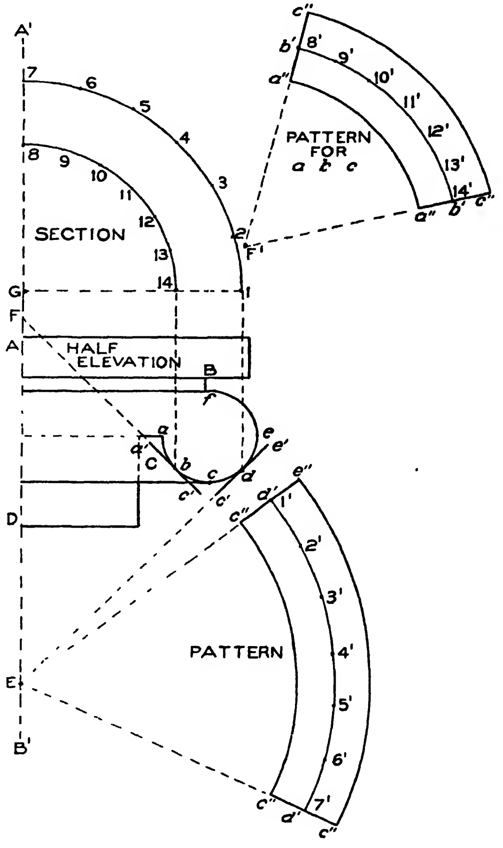


Fig. 343.

as shown from *b* to a' and from *b* to c'; also take the stretchouts of *d* to *c* and *d* to *e*, and place them from *d* to c' and from *d* to e' on lines drawn parallel respectively to *a c* and *c e* from points *b* and *d*. Extend the lines c' c' and c' a' until they intersect the center line A^1 B^1 at E and F respectively. From the points *b* and *d* erect lines intersecting the line G 1, drawn at right angles to A^1

B[1], at 14 and 1 respectively. Using G as center, and with radii equal to G 14 and G 1, describe quarter-sections, as shown. Divide both into equal parts, as shown from 1 to 7, and from 8 to 14. With E as center, and with radii equal to E *c′*, E *d*, and E *e′*, describe the arcs *c″ c″*, *d′ d′*, and *e″ e″*. From any point on one end, as *e″*, draw a radial line to E, intersecting the inner arcs at *d′* and *c″*. Now take the stretchout of the section from 1 to 7, and, starting at *d′*, lay off the stretchout as shown from 1′ to 7′. Through 7′ draw a line towards E, intersecting the inner arc at *c″* and the outer one at *e″*. Then will *c″ e″ e″ c″* be the quarter-pattern for that part of the bead shown by *c c*, also for *e f*, in elevation. For the pattern for that part shown by *a c*, use F[1] as center; and with radii equal to F *a′*, F *b*, and F *c′*, describe the arcs *a″ a″*, *b′ b′*, and *c″ c″*. From any point on the arc *b′ b′*, as 8′, lay off the stretchout of the quarter-section 8 14, as shown from 8′ to 14′. Through these two points draw lines towards F[1], intersecting the inner arcs at *a″ a″*; and extend them until they intersect the outer arc at *c″* and *c″*. Then will *c″ a″ a″ c″* be the desired pattern.

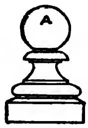


Fig. 344.

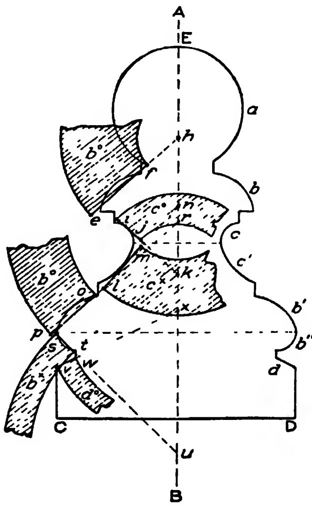


Fig. 345.

In Fig. 344 is shown an illustration of a round finial which contains moulds, the principles of which have already been described in the preceding problems. The ball A is made of either horizontal or vertical sections. In Fig. 345 is shown how the moulds in a finial of this kind are averaged. The method of obtaining the true length of each pattern piece will be omitted, as this was thoroughly covered in the preceding problems. First draw the center line A B; on either side of which draw the section of the finial, as shown by C D E. The blanks for the ball *a* will be obtained as explained in the Instruction Paper on Sheet Metal Work. The mould *b* is averaged as shown by the line *e f*, extending same until it intersects the center line at *h*, *e f* representing the stretchout of the mould obtained, as explained in the

paper on Sheet Metal Work. Using h as center, with $h\ f$ and $h\ e$ as radii, describe the blank b°.

In the next mould, $c\ c'$, a seam is located in same as shown by the dotted line. Then average C by the line $i\ j$, extending same until it meets the center line at k; also average c' by the line $l\ m$, extending this also until the center line is intersected at n. Then $i\ j$ and $l\ m$ represent respectively the stretchouts of the mould $c\ c'$, the blanks c° and c^{x} being struck respectively from the centers k and n. The mould $b'\ b''$ also has a seam, as shown by the dotted line, the moulds being averaged by the lines $p\ o$ and $s\ t$, which, if extended, intersect the center line at r and u. These points are the centers, respectively, for striking the blanks b° and b^{x}. The flaring piece d is struck from the

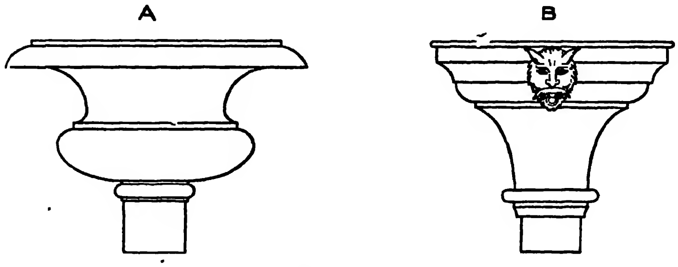


Fig. 346.

center x, with radii equal to $x\ w$ and $x\ v$, thus obtaining the blank d°.

By referring to the various rules given in previous problems, the true length of the blanks can be obtained.

The principles used for blanks hammered by hand can be applied to almost any form that will arise, as, for example, in the case shown in Fig. 346, in which A and B represent circular leader heads; or in that shown in Fig. 347, in which A and B show two styles of balusters, a and b (in both) representing the square tops and bases. Another example is that of a round finial, as in Fig. 348, A showing the hood which slips over the apex of the roof. While these forms can be bought, yet in some cases where a special design is brought out by the architect, it is necessary that they be made by hand, especially when but one is required.

The last problem on handwork is shown in Fig. 349—that of obtaining the blanks for the bottom of a circular bay. The curved moulding A will be hammered by hand or by machine, as will be ex-

plained later on, while the bottom B is the problem before us. The plan, it will be seen, is the arc of a circle; and, to obtain the various blanks, proceed as shown in Fig. 350, in which A B C is the elevation of the bottom of the bay, I J K being a plan view on A C, showing the

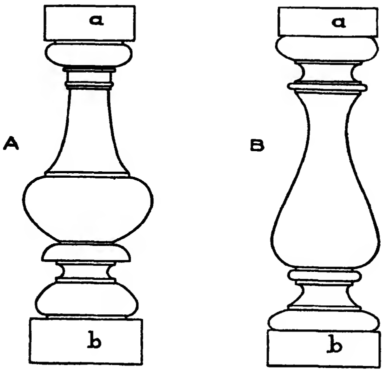


Fig. 347.

curve struck from the center H. In this case the front view of the bottom of the bay is given, and must have the shape indicated by A B C taken on the line I J in plan. It therefore becomes necessary to establish a true section on the center line S K in plan, from which to obtain the radii for the blanks or

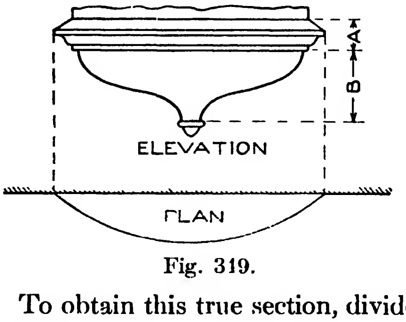


Fig. 319.

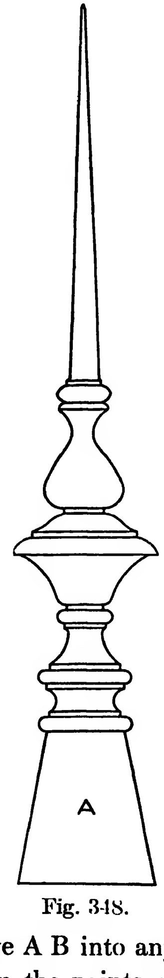


Fig. 348.

patterns. To obtain this true section, divide the curve A B into any number of equal parts, as shown from 1 to 6. From the points of division, at right angles to A C, drop lines as shown, intersecting the wall line I J at points 1′ to 6′. Then, using H as center, and radii equal to H 6′, H 5′, H 4′, H 3′, and H 2′, draw arcs crossing the center line D E shown from 1″ to 6″. At any convenient point

opposite the front elevation draw any vertical line, as T U. Extend the lines from the spaces in the profile A B until they intersect the vertical line T U as shown. Now, measuring in every instance from the point S in plan, take the various distances to the num-

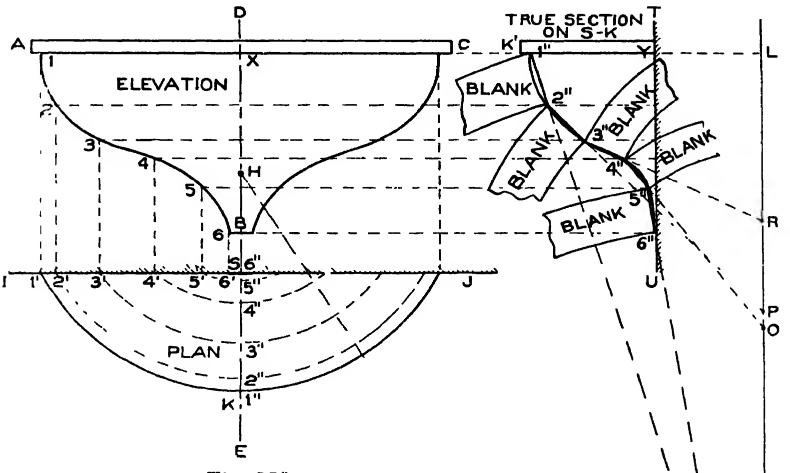


Fig. 350.

bered points in plan and place them upon lines of similar numbers, measuring in every instance from the line T U in section. Thus take the distance S K in plan, and place it as shown from the line T U to K^1; then again, take the distance from S to 2″ in plan, and place it as shown from the line T U to 2″ on line 2 in section. Proceed in this manner until all the points in the true section have been obtained. Trace a line as shown, when 1″ to 6″ to Y will be the true section on the line S K in plan.

It should be understood that the usual method for making the bottom of bays round in plan is to divide the profile of the moulding into such parts as can be best raised or stretched. Assuming that this has been done, take the distance from 1″ in plan to the center point H, and place it as shown from 1″ to L in section. From the point L, draw a vertical line L M, as shown. For the pattern for the mould 1″ 2″, average a line through the extreme points, as shown, and extend the same until it meets L M at N. Then, with N as center, and with radii equal to N 2″ and N 1″, describe

the blank shown. The length of this blank is obtained by measuring on the arc 1′ 1″ in plan, and placing this stretchout on the arc 1″ of the blank. The other blanks are obtained in precisely the same manner. Thus P is the center for the blank 2″ 3″; R, for the blank 3″ 4″; O, for the blank 4″ 5″; and M, for the blank 5″ 6″.

The moulds 1″ 2″, 2″ 3″, and 3″ 4″ will be raised; while the blanks 4″ 5″ and 5″ 6″ will be stretched.

APPROXIMATE BLANKS FOR CURVED MOULDINGS HAMMERED BY MACHINE

The principles employed in averaging the profile for a moulding to be rolled or hammered by machine do not differ to any material extent from those used in the case of mouldings hammered by hand.

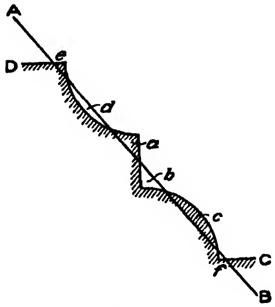


Fig. 351.

Fig. 351 shows the general method of averaging the profile of a moulding in determining the radius of the blank or pattern. It will be seen that A B is drawn in such a manner, so to speak, as to average the inequalities of the profile D C required to be made. Thus distances *a* and *b* are equal, as are the distances *c* and *d*, and *e* and *f*. It is very difficult to indicate definite rules to be observed in drawing a line of this kind, or, in other words, in averaging the profile. Nothing short of actual experience and intimate knowledge of the material in which the moulding is to be made, will enable the operator

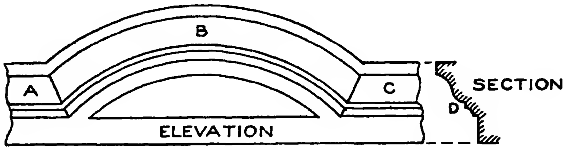


Fig. 352.

to decide correctly in all cases. There is, however, no danger of making very grave errors in this respect, because the capacity of the machines in use is such, that, were the pattern less advantageously planned in this particular than it should be, still, by passing it through the dies or rolls an extra time or two, it would be brought to the required shape.

In Fig. 352 is shown a part elevation of a circular moulding as it would occur in a segmental pediment, window cap, or other structure arising in sheet-metal cornice work. B shows the curved moulding, joining two horizontal pieces A and C, the true section of all the moulds being shown by D.

In this connection it may be proper to remark that in practice, no miters are cut on the circular blanks, the miter-cuts being placed on the horizontal pieces, and the circular moulding trimmed after it has been formed up.

In Fig. 353 is shown the method of obtaining the blanks for mouldings curved in elevation, no matter what their radius or profile

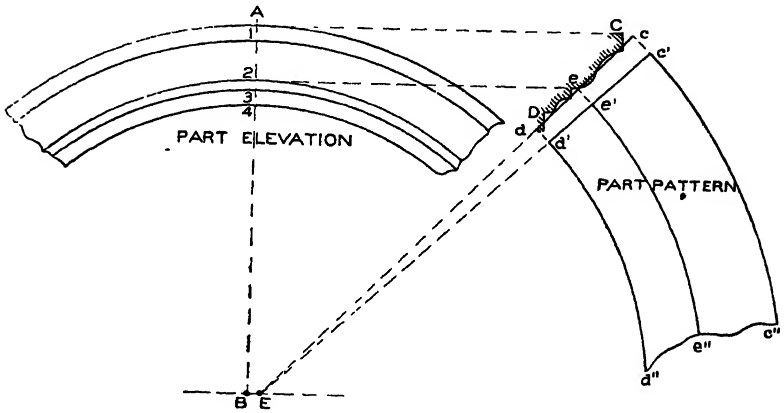


Fig. 353.

may be. First draw the center line A B, and, with the desired center, as B, describe the outer curve A. At right angles to A B, in its proper position, draw a section of the profile as shown by C D. From the various members in this section, project lines to the center line A B, as 1, 2, 3, and 4; and, using B as center, describe the various arcs and complete the elevation as shown by A B C in Fig. 352, only partly shown in Fig. 353. In the manner before described, average the profile C D by the line *c d*, extending it until it intersects the line drawn through the center B at right angles to A B, at E. Then E is the center from which to strike the pattern. Centrally on the section C D, establish *e* on the line *c d*, where it intersects the mould, and take the stretchout from *e* to C and from *e* to D, and place it as shown respectively from *e* to *c* and from *e* to *d* on the line *c d*. Now, using E as

the blank shown. The length of this blank is obtained by measuring on the arc 1′ 1″ in plan, and placing this stretchout on the arc 1″ of the blank. The other blanks are obtained in precisely the same manner. Thus P is the center for the blank 2″ 3″; R, for the blank 3″ 4″; O, for the blank 4″ 5″; and M, for the blank 5″ 6″.

The moulds 1″ 2″, 2″ 3″, and 3″ 4″ will be raised; while the blanks 4″ 5″ and 5″ 6″ will be stretched.

APPROXIMATE BLANKS FOR CURVED MOULDINGS HAMMERED BY MACHINE

The principles employed in averaging the profile for a moulding to be rolled or hammered by machine do not differ to any material extent from those used in the case of mouldings hammered by hand.

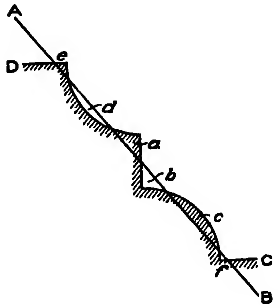


Fig. 351.

Fig. 351 shows the general method of averaging the profile of a moulding in determining the radius of the blank or pattern. It will be seen that A B is drawn in such a manner, so to speak, as to average the inequalities of the profile D C required to be made. Thus distances *a* and *b* are equal, as are the distances *c* and *d*, and *e* and *f*. It is very difficult to indicate definite rules to be observed in drawing a line of this kind, or, in other words, in averaging the profile. Nothing short of actual experience and intimate knowledge of the material in which the moulding is to be made, will enable the operator

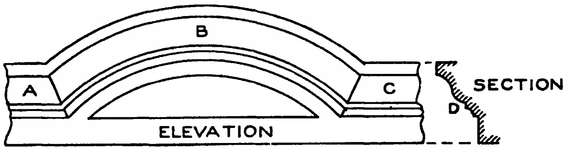


Fig. 352.

to decide correctly in all cases. There is, however, no danger of making very grave errors in this respect, because the capacity of the machines in use is such, that, were the pattern less advantageously planned in this particular than it should be, still, by passing it through the dies or rolls an extra time or two, it would be brought to the required shape.

In Fig. 352 is shown a part elevation of a circular moulding as it would occur in a segmental pediment, window cap, or other structure arising in sheet-metal cornice work. B shows the curved moulding, joining two horizontal pieces A and C, the true section of all the moulds being shown by D.

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In Fig. 353 is shown the method of obtaining the blanks for mouldings curved in elevation, no matter what their radius or profile

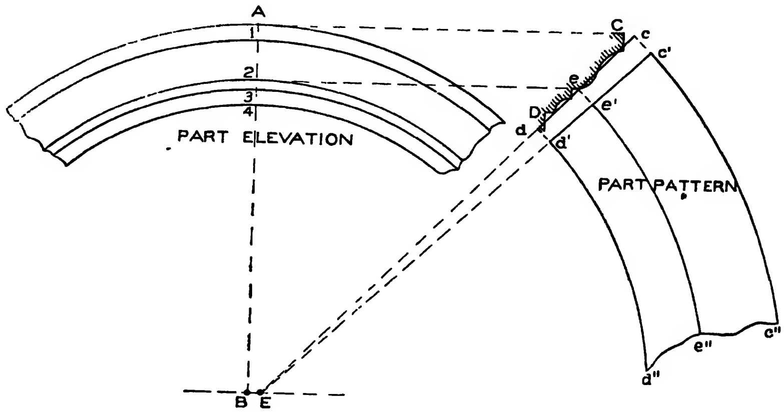


Fig. 353.

may be. First draw the center line A B, and, with the desired center, as B, describe the outer curve A. At right angles to A B, in its proper position, draw a section of the profile as shown by C D. From the various members in this section, project lines to the center line A B, as 1, 2, 3, and 4; and, using B as center, describe the various arcs and complete the elevation as shown by A B C in Fig. 352, only partly shown in Fig. 353. In the manner before described, average the profile C D by the line *c d*, extending it until it intersects the line drawn through the center B at right angles to A B, at E. Then E is the center from which to strike the pattern. Centrally on the section C D, establish *e* on the line *c d*, where it intersects the mould, and take the stretchout from *e* to C and from *e* to D, and place it as shown respectively from *e* to *c* and from *e* to *d* on the line *c d*. Now, using E as

center, with radii equal to E d, E e, and E c, describe the arcs d' d'', e' e'', and c' c''. Draw a line from c' to E, intersecting the middle and inner arc at e' and d'. The arc e' e'' then becomes the measuring line to obtain the length of the pattern, the length being measured on the arc 2 in elevation, which corresponds to the point e in section.

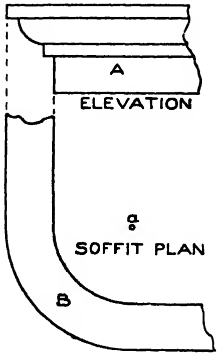


Fig. 354.

In Fig. 354 is shown the elevation of a moulding A curved in plan B, the arc being struck from the given point a. This is apt to occur when the moulding or cornice is placed on a building whose corner is round. To obtain the pattern when the moulding is curved in plan, proceed as shown in Fig. 355. Draw the section of the moulding, as A B, A C being the mould for which the pattern is desired. C B represents a straight strip which is attached to the mould after it is hammered or rolled to shape. In practice the elevation is not required. At pleasure, below the section, draw the horizontal line E D. From the extreme or outside edge of the mould, as b, drop a line intersecting the horizontal line E D at E. Knowing the radius of the arc on b in section, place it on the line E D, thus obtaining the point D. With D as center, describe the arc E F, intersecting a line drawn at right angle to E D from D. Average a line through the section, as G H, intersecting the line D F, drawn vertical from the center D, at J. Establish at pleasure the stationary point a, from which drop a line cutting E D at a'. Using D as center, and with D a' as radius, describe the arc a' a'', which is the measuring line when laying out the pattern. Now take the stretch-

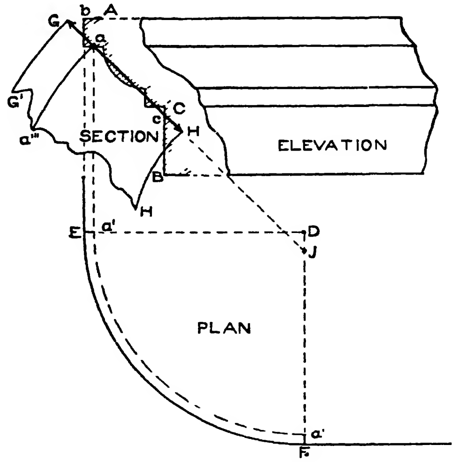


Fig. 355.

outs from a to b and from a to c, and place them on the averaged line from a to G and from a to H respectively. Using J as center, with radii extending to the various points G, a, and H, describe the arcs G G^1, a a''', and H H^1. On the arc a' a''', the pattern is measured to correspond to the arc a' a'' in plan.

In Fig. 356 is shown a front view of an ornamental bull's-eye window, showing the circular mould A B C D, which in this case we desire to lay out in one piece, so that, when hammered or rolled in the machine, it will have the desired diameter. The same principles can be applied to the upper mould E F, as were used in connection with Figs. 352 and 353.

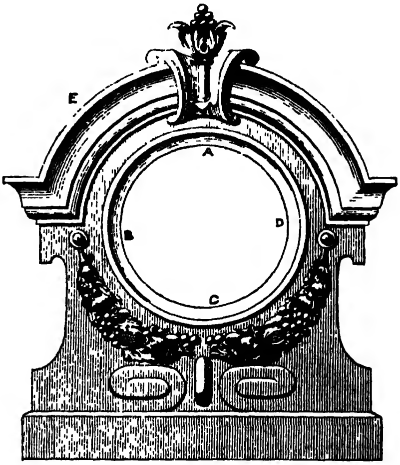


Fig. 356.

To obtain the blank for the bull's-eye window shown in Fig. 356, proceed as shown in Fig. 357. Let A B C D represent the elevation of the bull's-eye struck from the center E. Through E draw the hori-

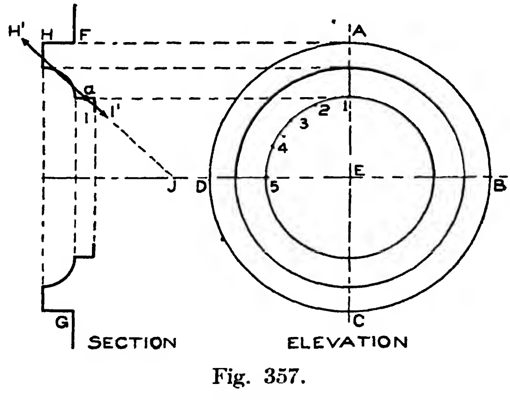


Fig. 357.

zontal and perpendicular lines shown. In its proper position, draw a section of the window as shown by F G. Through the face of the mould, as H I, average the line H^1 I^1, extending it until it intersects

the center line B D at J. Where the average line intersects the mould at *a*, establish this as a stationary point; and take the stretchouts from *a* to I and from *a* to H, and lay them off on the line $H^1 I^1$ from *a* to I^1 and *a* to H^1 respectively. As 1 5 in elevation represents the quarter-circle on the point *a* in section, divide this quarter-circle into equal spaces, as shown. Now, with radii equal to J I^1, J *a*, and J H^1, and with J in Fig. 358 as center, describe the arcs H H, *a a*, and I I. From any point, as H, on one side, draw a line to J, intersecting the middle and inner arcs at *a* and I. Take the stretchout of the quarter-circle from 1 to 5 in elevation in Fig. 357, and place it on the arc *a a* as shown from 1 to 5. Step this off four times, as shown by 5′, 5″, and 5‴. From J draw a line through 5‴, intersecting the inner and outer arcs at I and H. Then will H *a a* H be the full pattern.

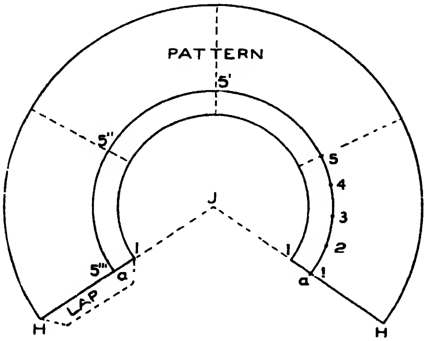


Fig. 358.

PLATE X

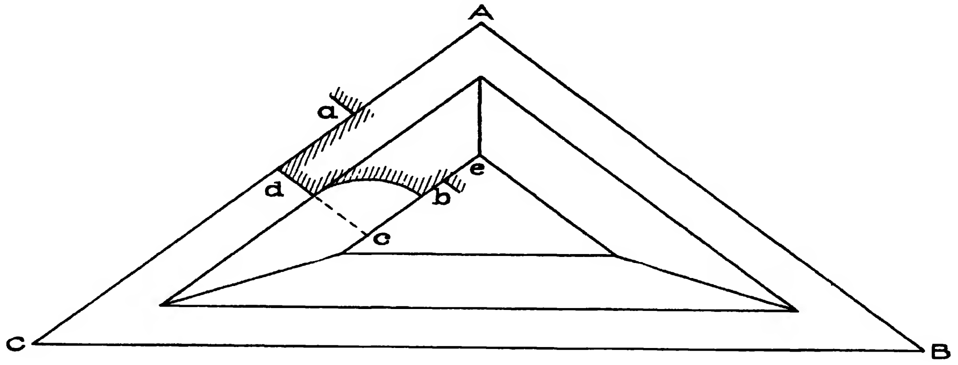
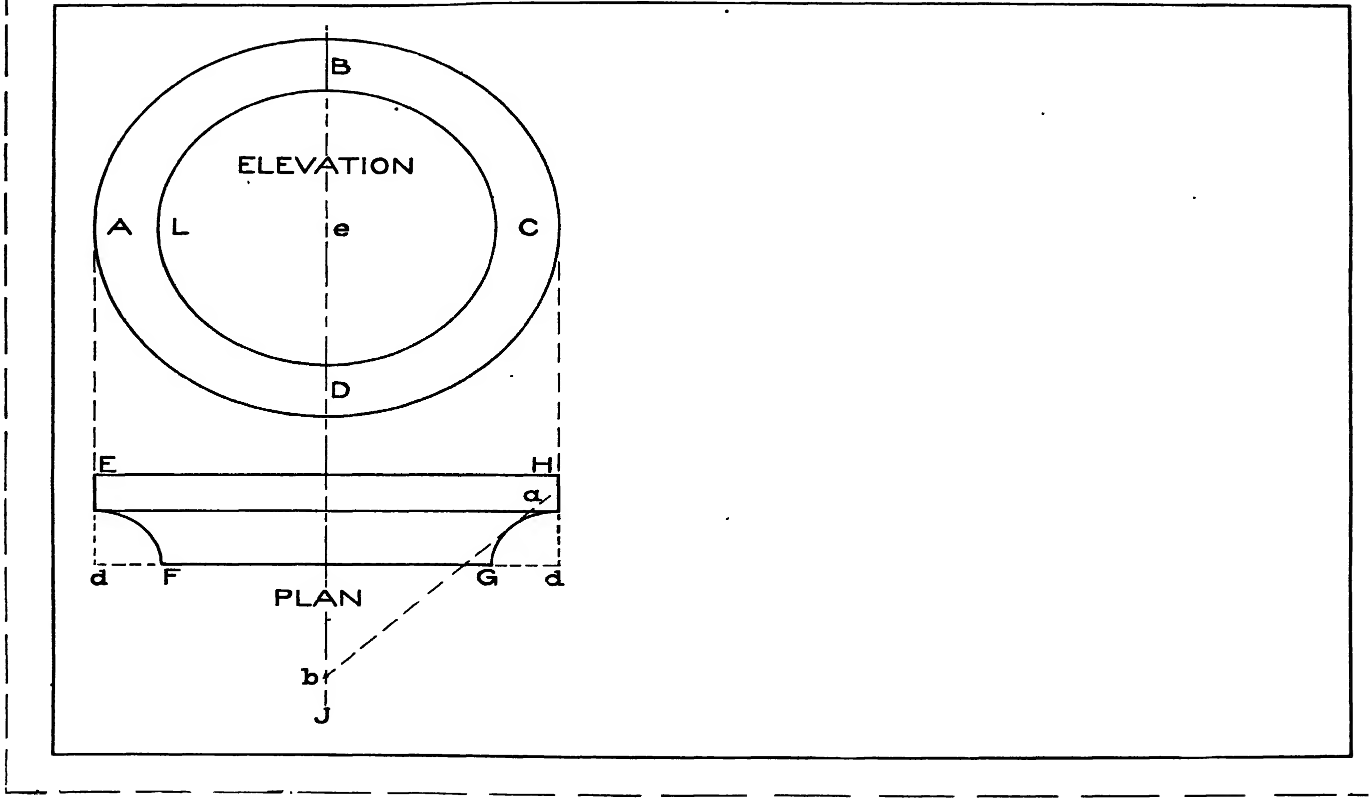


PLATE XI



EXAMINATION PLATES.

The plates of this Instruction Paper should be laid out the same size as the plates in Tinsmithing and Sheet-Metal Work (Parts I, II, and III). The border lines should be drawn as there described. Before starting on the drawings which will be sent to the School, the student should first practice on other paper, then copy and send corrected drawings for examination.

PLATE X—TRIANGULAR PANEL

A B C represents the outline of a triangular panel. When drawing this, make the line C B $9\frac{3}{4}$ inches long, 3 inches above the lower margin line and in the center of the length of the sheet. Place the point A 5 inches above and in the center of C B.

Draw the profile of the mould in the position shown, making the face width *a b* $1\frac{1}{4}$ inches, the projection from A to *d* $1\frac{1}{8}$ inches, the projection of *b* $\frac{3}{8}$ inch, the face *d* $\frac{1}{2}$ inch; and, using *c* as center, with a radius equal to $\frac{3}{4}$ inch, strike the cove *d b*. Then proceed to lay out the pattern for the one side of the panel shown by A C *c e* at right angles to A C, using the method given in Fig. 284.

PLATE XI—CIRCULAR PANEL

Three inches from the left margin line, draw the center line B J. Three inches below the upper margin line, on the line B J, locate *e*. Using *e* as center, with radius equal to $2\frac{1}{2}$ inches, draw the outer circle A B C D. Then, with a radius equal to A L in elevation, or $\frac{3}{4}$ inch, draw the coves shown in plan, which completes the plan view by drawing F G. Now obtain the pattern in *one piece* for the cove O, by averaging the line *a b* as shown, being careful to follow the rule given in connection with Fig. 341, and place the pattern in the center of the space in Plate XI.

PLATE XII—GABLE MOULDING ON A WASH

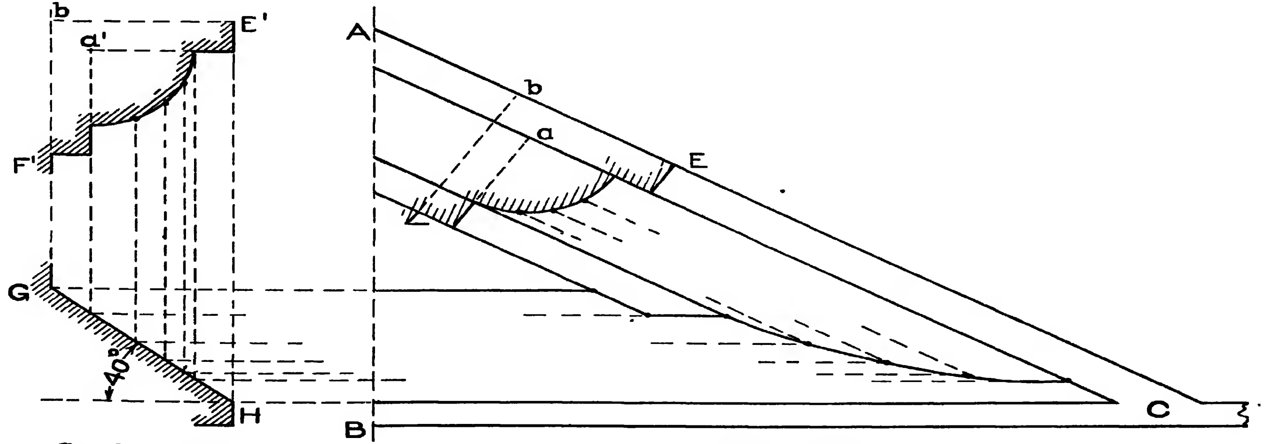
Draw the center line A B $4\frac{1}{2}$ inches from the left margin line, $\frac{3}{4}$ inch above the bottom, and 3 inches below the top. Make the length of the line B C $8\frac{3}{4}$ inches, $1\frac{3}{8}$ inches above the bottom margin.

Make the height of the lower member C $\frac{3}{8}$ inch. Make the distance from the center line A B to the point C $8\frac{1}{4}$ inches, and the distance from B to A $5\frac{5}{8}$ inches, and draw a line from C to A, giving the desired pitch. Parallel to A C, draw the face view of the members of the mould, making the upper fillet $\frac{1}{2}$ inch, the cove 1 inch, and the lower fillet $\frac{3}{8}$ inch. From A, locate *b* at a distance of $2\frac{1}{8}$ inches. Draw the perpendicular *b* F. Make the projection from *b* to E $1\frac{3}{4}$ inches. Make the projection of the upper and lower fillets each $\frac{3}{8}$ inch; and, using *a* as center, with a radius equal to 1 inch, draw the quarter-round shown. Now draw a section of the wash G H, placing it centrally between the line A B and margin; place H in its relative position to B; and from H, at an angle of 40 degrees, draw H G. Four and one-fourth inches above the point G, draw a duplicate of the profile E *b* F, as shown by E^1 F^1 b'. Then proceed to obtain the miter-line in elevation, and lay off the pattern at right angles to A C in the manner explained in connection with Fig. 299.

PLATE XIII—REDUCED MITER

In this plate is shown the soffit plan of a reduced miter in which the profile is given for the front piece and must return in a given distance at the side. Three and one-fourth inches below the upper margin, draw A B 2 inches long, the corner B to be $5\frac{3}{4}$ inches from the right margin. Make the distance from B to C $\frac{3}{4}$ inch, and from C to D $4\frac{1}{4}$ inches. Draw the outline of the front mould $1\frac{1}{2}$ inches from and parallel to C D, and the outline of the return mould 1 inch from and parallel to B C. On the line C D, $1\frac{1}{8}$ inches from C, locate the point *b*, then construct the profile G as shown, making *b c* equal to $2\frac{1}{4}$ inches. Make *c* equal to $\frac{3}{8}$ inch; *d* equal to 1 inch; *e* equal to $\frac{3}{8}$ inch; *f* equal to $\frac{1}{2}$ inch; and with a radius equal to $\frac{3}{4}$ inch, strike the cove shown, using *a* as center. Above the line A B, obtain the true profile for the return A B C F, and lay off this pattern at right angles to A F centrally between A F and the margin line. Also lay off the pattern for the front F C D E at right angles to F E, centrally between the line F E and the lower margin line, following the rules given in connection with Fig. 320.

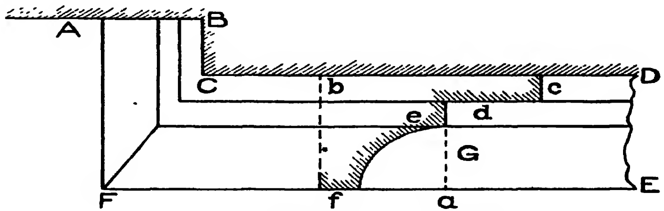
PLATE XII



SECTION

ELEVATION

PLATE XIII



SOFFIT PLAN

PRACTICAL PROBLEMS IN MENSURATION FOR SHEET METAL WORKERS.

A square tank, Fig. 1, is required whose capacity should be 200 gallons, the sides *b a* and *a c* each to be 30 inches; how high must *c d* be, so that the tank will hold the desired quantity?

Suppose the height *c d* is to be $51\frac{1}{3}$ inches, and the tank is to

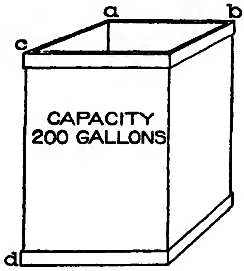


Fig. 1.

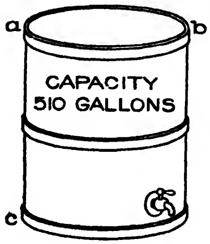


Fig. 2.

have similar capacity, and one side *c a* is to be 20 inches wide, how long must the alternate side *a b* be, so that the tank will hold 200 gallons?

A round tank, Fig. 2, is to be constructed whose capacity should equal 510 gallons, and be 5 feet high from *c* to *a*; what must its diameter *a b* be, so as to hold the desired capacity?

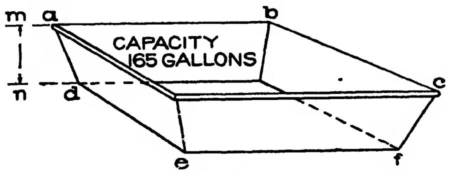


Fig. 3.

Suppose the diameter of the tank is to be 50 inches as *a b*; what must its height *a c* be, so that the tank will hold 510 gallons?

A large drip pan, Fig. 3, is to be constructed whose capacity should be 165 gallons, and whose top measurements *a b* and *b c* are 60 × 40 inches respectively, and bottom measurements *d e* and

$e\,f$ 34 × 54 inches respectively; what must its height $m\,n$ be, so as to hold the desired volume?

A round tapering measure, Fig. 4, is to be constructed whose volume will equal 42 quarts; its bottom diameter $a\,b$ is to be 14

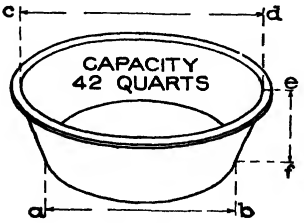


Fig. 4.

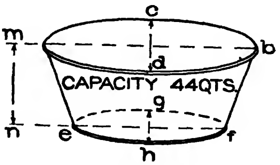


Fig. 5.

inches, its top diameter $c\,d$ 18 inches; what must its height $e\,f$ be to hold the desired quantity?

An elliptical tapering tank, Fig. 5, is to be constructed whose major axis $m\,b$ is 24 inches, and minor axis $c\,d$ 14 inches at the top, while at the bottom the major axis $e\,f$ is 20 inches, and minor axis $g\,h$ 10 inches; the capacity of the tank should equal 44 quarts; what must the height $m\,n$ be, so that the tank will hold the desired amount?

A tank, Fig. 6, is to be constructed with semicircular ends

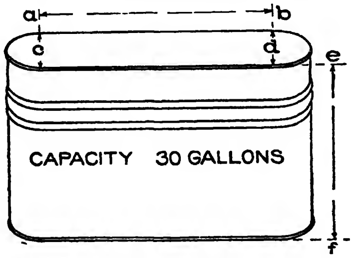


Fig. 6.

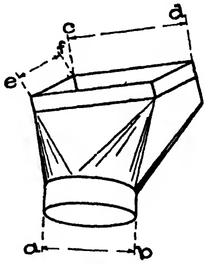


Fig. 7.

whose capacity should equal 30 gallons; the length $a\,b$ to be 20 inches, and the diameters of c and d to be each 10 inches; what must the height $e\,f$ be, so that the tank will hold the desired quantity?

Suppose the height $e\,f$ is to be 24 inches, the diameters c and d each 11 inches; what must the length of $a\,b$ be, so that the tank will hold 30 gallons?

In Fig. 7 is shown a fitting used in ventilation piping; the diameter *a b* is $11\frac{1}{4}$ inches and it is desired that the oblong pipe on the opposite end shall have an area similar to the round pipe *a b*; if *e f* must be 5 inches, what must *c d* be so that both areas are alike?

Suppose the pipe is to be square in place of oblong, what must the length of each side be, so that both ends have similar area?

In Fig. 8, *a b* is 40 inches in diameter; and each one of the branches *c*, *d*, and *e* are to have equal diameters, what must the diameter of the branches be, so that the combined area of *c*, *d*, and *e* will equal the area of *a b*?

If *c* is 10 inches in diameter, *d* 12 inches, and *e* 8 inches, what must be the diameter of *a b*, to have the combined area of the branches?

Fig. 9 shows a transition piece from a round pipe *a* to an

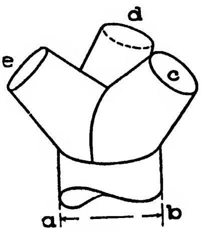


Fig. 8.

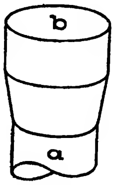


Fig. 9.

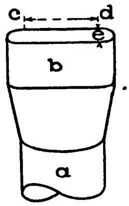


Fig. 10.

elliptical pipe *b*, both sections to have similar area; if the round pipe is 24 inches in diameter, and the major axis of the elliptical pipe must be 32 inches, what must the minor axis of *b* be so that the area at *b* will equal the area of *a*?

If the minor axis of *b* is to be 16 inches and the major axis 35 inches, what must the diameter of *a* be, so that both sections will have similar area?

In Fig. 10, *a* is 20 inches in diameter and forms a transition to an oblong pipe with semicircular end; the semicircular ends are to be 10 inches in diameter; what must the length of *c d* be, so that the area of *b* will be equal to the area of *a*?

If the pipe *b* measured 40×11 inches, having semicircular ends, what must the diameter of *a* be, so that both sections are equal in area?

If *a* is 20 inches in diameter and the upper section was to be

rectangular in shape, 8 inches wide, what would the length of the upper section be?

Suppose the upper section *b* was desired to be square, what must the length of each side be, to have an area similar to *a*?

In Fig. 11 is shown the illustration of an ordinary steel square, and the method is given of obtaining accurate diameters of pipes, round or square, without any computation whatever, the rule being based on the geometrical principle that the square of the hypothenuse of a right angle triangle is equal to the sum of the squares of its base and altitude. To illustrate the rule, Fig. 12 has been

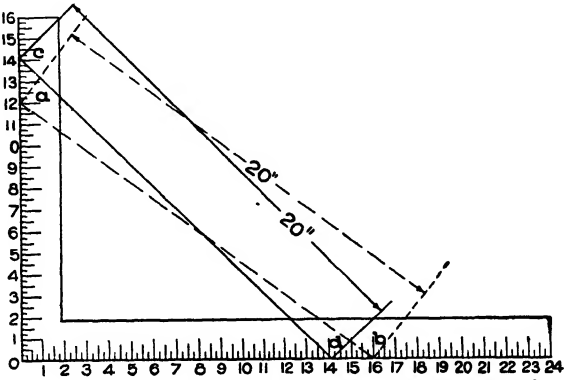


Fig. 11.

prepared. Let A represent a round or square pipe, 20 inches across, and B a round or square pipe 12 inches across; it is desired to take a branch from the main so that the two branches B and C will equal the area of the main A. What must the size of C be?

The size of C is found by simply taking a rule 20 inches long and placing one end on the arm of the square in Fig. 11, on the number 12, when the opposite end of the rule will touch the number 16. Then 16 is the required size of the branch C in Fig. 12. We can prove this by computation which, however, is not necessary in practice. The area of a 20-inch round pipe equals 314.16 in.; area of 12-in. pipe = 113.098 in.; area of 16-in. pipe = 201.062 in.; and 113.098 in. + 201.062 in. = 314.160 in. The area of a 20-in. square pipe = 400 in.; area of 12-in. square pipe = 144 in.; area of 16-in. square pipe = 256 in.; and 256 in. + 144 in. = 400 in.

Suppose any two branches are given as B and C in Fig. 12, what must the size of A be so that its area will have the combined area of the two branches?

Simply set the rule on the numbers 12 and 16 on the two arms of the square respectively, and the length from a to b in Fig. 11 will measure 20 inches.

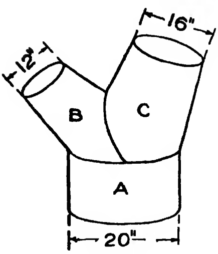
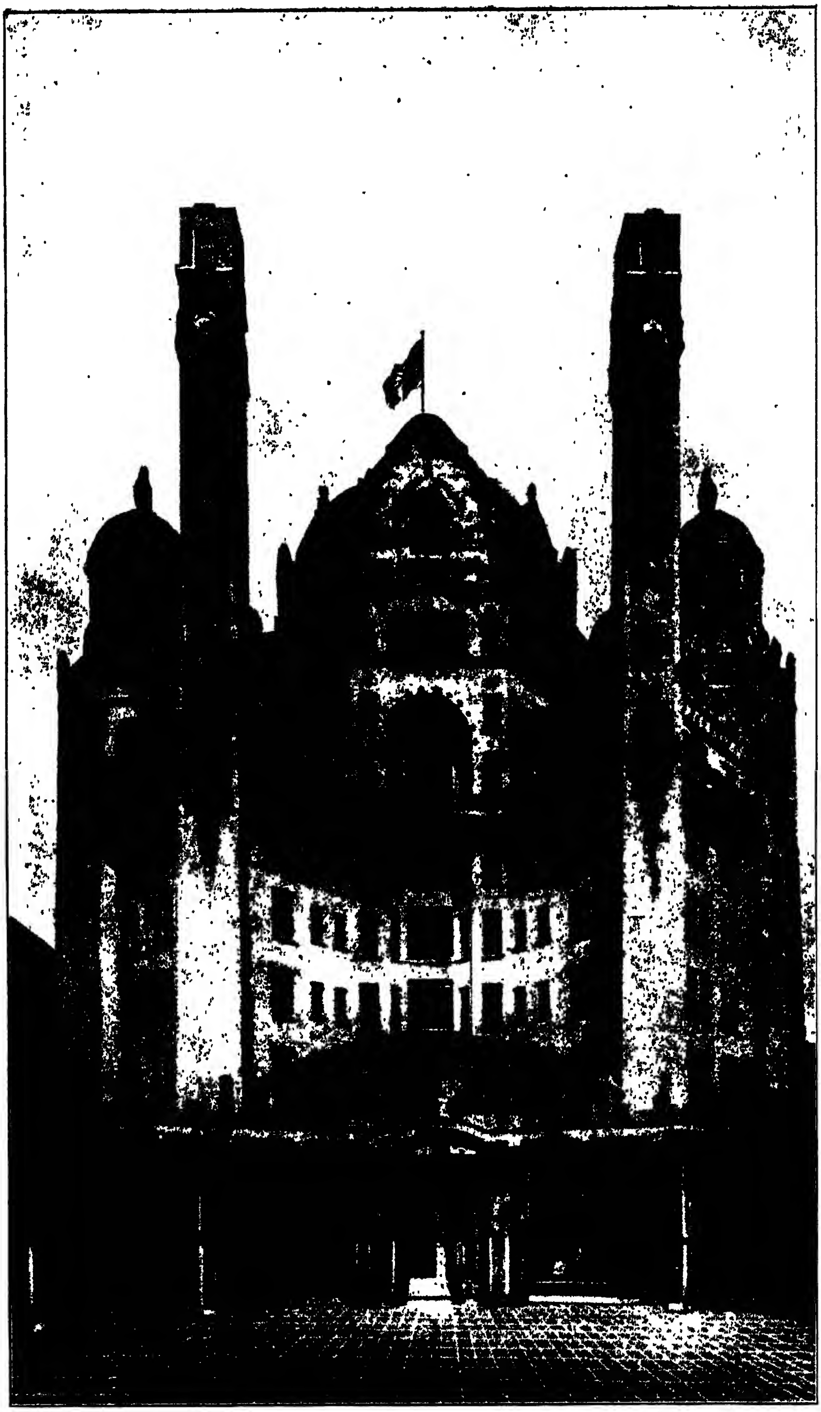


Fig. 12.

If A, Fig. 12, were given, and two branches were required, so that B and C were both of equal size, then simply set the rule 20 inches long, on both arms of the square so that the distance from O to c and O to d would be equal, as shown in Fig. 11, which would be found to measure $14\frac{1}{7}$ in. plus a least trifle. This rule can be used to advantage for any size round or square pipe in blower, blast, heat, and ventilating piping, saving time and trouble in computation. Where no square is at hand, one can be drawn on paper and used for work of this kind.

GATE LODGE OF J. H. MOORE AT LAKE GENEVA, WIS.
Jarvis Hunt, Architect, Chicago, Ill.
Roofs Covered with Shingle Tiles, Dull Browns and Dull Greens, the Tile for the Gables being Specially Burned.
Reproduced by Courtesy of Ludovici-Celadon Company.



HOTEL MARLBOROUGH-BLENHEIM, ATLANTIC CITY, N. J.

This Magnificent Structure, Built Throughout of Reinforced Concrete is Especially Noteworthy as the Most Elaborate Application which has Yet been Made of this New Material of Construction. It is Located Near the Famous "Boardwalk," Overlooking the Ocean.

PLASTERING

The subject of plastering in relation to modern dwellings is necessarily divided into two sections. The first treats of the plastering of walls on the *interior* of the house; the second will briefly describe some of the various ways of finishing in cement plaster the house *exterior*.

INTERIOR PLASTERING

The installation of interior plastering marks the division between the completion of the *rough work* on the residence, and the very beginning of the placing of the *finish* that is to follow.

The plastering cannot be started until the walls and ceilings have been lathed, and the ceilings must be furred before even the lathing can be begun. When the building is ready for lathing, all of the rough studding, framework, and partitions must be set in place; and the piping and wiring necessary in the plumbing, heating, lighting, etc., of the dwelling, must be installed and tested before the lathing or furring can be started.

The apparent break in the progress of building necessary to lath, plaster, and dry out a house, need not be altogether time lost for any of the various trades. Those unable to resume work until this intermediary process has been completed, can be securing their necessary materials and fixtures and arranging them ready for installation. The carpenter can be getting out his mill work and finish, be ready to put in his window-sash, set his standing finish in place around doors and windows, lay the upper floors, etc., and complete the remainder of his contract. The painter and paperer then commence their work; the electricians, plumbers, and heating contractors install their service fixtures, and the dwelling is soon ready for occupation.

The studs of a building are spaced sixteen inches apart on centers, so that each lath receives four nailings. Each end of the lath rests upon the center of a stud; and the two intermediate studs provide fastenings at spaces equally distant in its length. The ceilings are

customarily furred to provide lath nailings, four—and in better work, five—nailings to the lath, with furrings seven-eighths of an inch thick and one and one-quarter inches or more wide, running crosswise of the floor joists. This furring is intended to level up the bottom of the joists, and distributes the unequal result of their skrinkage or uneven settlement from the weight above, thus preventing plaster cracks.

Before beginning lathing, the carpenter should see that each partition, at its intersection with another wall, is started with a stud nailed directly against the crossing studding. This makes it impossible for the lather to run the ends of his laths in behind or over the partitions—a careless practice that provides a very unstable internal plaster angle. The carpenter also sets plaster furrings, three-quarters of an inch thick, around all window and door openings and around the walls at the height of the top of his base skirting, so as to mark the points where the work of both plasterer and lather end, and to provide nailings for the finish woodwork. It is essential for the carpenter to place any necessary furring for cornices, door-caps, etc., before the lathing is begun; also any other furring blocks that may be required by the plumber to secure the setting of his fixtures or to support and carry his pipes.

LATHING

Wood Laths. Wood laths are put up in bundles of 100 laths; and are nailed upon the studdings of the wooden frame, with a space of one-quarter inch between them. This distance is sufficient to allow for lath shrinkage or swelling, and still provide a firm clinch for the plastering. If the space is much less than this, the plaster clinch will be weakened. If much more, the laths may possibly sag down on the ceilings with the extra weight of plaster. In no instance should these spaces between laths exceed a width of three-eighths of an inch.

The *clinch*, or *key*, of the plaster is formed by the mortar being pressed through the spaces between the laths and then spreading out back of the laths upon both sides of the crack, so forming a tie, or clinch, that holds the mortar firmly and securely in place.

It occasionally becomes necessary to lath on very thin furrings to cover over a heating pipe, a brick or iron support, or some other such exceptional instance of construction. In that case a wider space

between the laths may strengthen the plaster clinch; or, better still, a strip of expanded metal may be used over or around such obstructions.

The best wooden laths are made of pine or spruce, and are only partially seasoned. They should be free from sap, bark, and dead knots. Both bark and knots are likely to loosen from the surrounding wood and so destroy the hold of the plaster; while the face of the plaster is occasionally stained from pitchy knotholes, bark, or sap. All laths are now machine-sawn. The old-fashioned split lath has not been in the market for now more than fifty years.

If the laths are too dry, the wet mortar is likely to cause them to warp and twist; and if it hardens or sets before the laths become saturated, their swelling is likely to produce parallel plaster cracks. Better results can be obtained by using wet laths, when both mortar and laths dry out together.

In specifying the nailing of wood laths, it is sometimes thought to ensure better work if two nailings are required at each end of the lath, either upon the ceiling alone or upon both wall and ceiling. It is more than doubtful if this requirement produces the desired result, as two nails in the lath end are likely to start a split, which may be increased by the pressure necessary in applying the mortar, until the entire end of the lath is partially or wholly loosened from its support before the plastering is all upon the wall. Large lath nails, instead of making the work more secure, weaken it in the same way. The common-sized inch-and-one-eighth long—"three-penny fine"—nails fasten the laths securely, even the ceiling nails rarely pulling out. About five pounds of nails will be necessary to each one thousand laths.

The joints of laths are ordinarily broken every eight courses. This means that not more than eight adjoining lath ends are nailed upon one stud or furring, the next eight laths, in both directions, being carried by, ending upon the next wall stud or ceiling furring to either right or left, thus alternating the break and obviating the possibility of an extended crack occurring at the line of lath jointure. Some lathers find a small handful of these laths more convenient to handle than a larger bundle, in which case it is simpler and easier for them to break joints every six laths—which is equally good construction. Occasionally studding is placed twelve inches apart, and the lath joints broken for every other lath. Such precautions, however, are

not necessary in the ordinary dwelling. They increase expense; and the closer spacing of the studs, especially, provides more undesirable weight to be carried by the house frame.

Wherever the wood studding of partitions comes up against the brickwork of chimneys or a terra-cotta or brick wall, strips of expanded metal or wire-mesh lath should be employed, extending seven or eight inches over upon either side of such a joint; and, if such a joint occurs in an internal angle, future cracking from a difference in settlement or shrinkage may be prevented by cutting through each plaster coat, when soft, with a sharp trowel.

Metal Lath. Of late years many varieties of metal lath have been placed upon the market. The use of such lath is generally required on boiler-room ceilings, and in other places exposed to strong artificial heat. Many varieties of metal lath—including all those made of wire—require supports at closer intervals than is provided by the studding, nine inches being generally considered the best distance. This necessitates either a closer spacing of studs than is otherwise necessary or desirable, or a series of furrings fastened to the wall studding.

There are some metal laths—generally those made on the expanded principle—that are sufficiently stiff, in one direction, to allow of a spacing of supports greater than nine inches; but, for ordinary wire cloth, no wider distance should ever be allowed, unless the cloth is itself artificially stiffened. All metal lath should be securely fastened by staples, and stretched before nailing, to increase its stiffness as much as possible.

In using metal lath, care should be taken to prevent plaster cracks along the line of jointure. The use of metal lath also requires three coats of plaster, in order to stiffen the lath sufficiently to resist the pressure required to finish the last coat.

Lathing and plastering are generally estimated, and the various materials are all figured, by the square yard. In small work, no openings are deducted unless they exceed sixty square feet in area. In figuring up plaster by quantity, when openings are allowed for, it is sometimes customary to add half of the contents when measuring closets; while small triangular wall pieces are figured as though square, in order to make up for the extra amount of labor required in plastering such restricted or odd-sized surfaces.

The use of expanded metal or wire lath is frequently demanded

by the building laws of some cities, and is always required on a fire-proof or first-class building.

Several makes of *plaster board* are in the market and being extensively advertised. They come in eight inch wide boards or large sheets of 32 by 36 inches, and are nailed directly upon the wall framing. One coat of plaster—in three-coat work—may then be dispensed with. These boards save time, being rapidly set in place even by unskilled carpenters, and the plaster itself drys out much more rapidly. They are, however, frequently the cause of cracks that appear in the finished plaster where the edges of the boards come together—sometimes even after the wall has been papered.

PLASTER MATERIALS

Plaster is principally composed of *lime*, *sand*, *hair*, and *water*.

Lime is obtained in different sections of the country from calcined limestone, the carbonic acid and moisture contained in the stone being driven off by the burning process. The whole theory of plastering is based upon the reduction of limestone to lime, and its chemical recombination, when distributed upon the walls of a house, into something approaching its original state. The *slaking* of the lime provides the moisture necessary for the process of crystallization that produces the *set* of the mortar; while the sole purpose of applying it upon the wall in several coats is to present that much more surface to absorb the carbonic acid—of which it was originally deprived in burning—from the air. The thinner the coats and the larger their total exposed surface, the greater the absorption of this strengthening constituent. For this reason—and solely for this reason—is three-coat plaster work to be considered as better than two.

Properly burnt lime slakes easily and completely, when water is added, until it is converted into a fine dust, which, in its turn, is moistened and turned into a paste under action of the water, which bubbles and hisses with the heat generated by the process. This is what is called the *slaking* of lime. Very rich and pure lime—the best for plastering—increases to about twice its original bulk by being slaked, and is then almost pure white in color. Lime should always be as fresh as possible, and must be delivered in tightly sealed barrels. Care should also be taken to ascertain that it has been burned with wood and not with coal.

Sand is broken or rotten rock which has become decomposed spontaneously or by the action of running water. That made by running water, or from stones worn small by rolling over and over upon the beach, is composed of particles so nearly round in contour and so lacking in angularities of surface that they are not good material for mixing in any mortar where *strength* is a requisite or necessity. The particles of rotten rock decomposed by exposure are better adapted to make good sand for mixing with mortar, their shape being more irregular, with many sharp and angular corners. Sand obtained from ledge stones contains the essential elements of those stones, quartz, feldspar, and mica being present in granite formations, and lava, obsidian, etc., in volcanic sand. The sand coming from the softer stones is generally more thoroughly disintegrated, being frequently so rotten as to be entirely unsuitable for use in plastering. In most parts of the country the principal supply of sand now comes from the beds of ancient lakes or rivers, and is called *pit sand.* True sand, no matter how fine, may always be distinguished from dust by dropping it into a glass of water, as it will invariably sink to the bottom without leaving any appreciable dirt upon the surface.

For plastering purposes, sharply angular sand is not absolutely essential. Good river sand, the coarser the better, is obtained so easily, and is so clean and free from dirt, clay, and earth stains, that it is most generally employed for plaster.

The third necessary constituent is *hair.* The best hair upon the market is cattle hair obtained from the tanneries. The hair should be of good length; and, if too lumpy or clotted, it should be separated by soaking in water the day before mixing it with the mortar, as this method of separating the hair is less dusty and more healthful than beating or whipping it dry to obtain the same result.

Occasionally brick dust is added to the mortar for coloring, when it is likely that the mortar will set more rapidly—especially if the dust is mixed in shortly before using and is dry at the time of mixing. All brick dust should be sifted through a fine sieve. Besides brick dust, a variety of colorings for mortar are used—such as lampblack, ivory black, powdered charcoal, Spanish brown, raw umber, burnt umber, red aniline, Venetian red, Indian red, vermilion, ultramarine blue, indigo blue, chrome yellow, and, occasionally, pulverized clay. Mineral colors should be preferred to earth colorings. The latter

weaken the plaster, and fade rapidly. Variously colored sands —when they can be obtained—make the best and most durable materials possible for tinting the final plaster coat.

It is impossible to state arbitrary, set, hard-and-fast proportions for the mixing of plastering for either exterior or interior work. The different makes of lime and grades of sand, alone, vary sufficiently to make any such statements exceedingly inadvisable; while the purpose and conditions under which the plaster is to be used, frequently occasion considerable changes in its proportions.

"Working" the Lime. The first process in the making of plaster is the *slaking* of the lime. This consists, as already said, in simply reducing the hard, brittle lumps of its original form to a smooth paste by mixing it with water. It is of the utmost importance that the lime should be entirely and completely slaked, and the paste smoothly and evenly *worked*, before adding any of the other ingredients.

The lime is slaked in a *mortar-bed*, a box of boards about 4 feet wide and 7 feet long, and a foot to eighteen inches high, set in some convenient location with its bottom about level with the top of a second box placed at one end, and about two feet lower in grade. Both mortar-and lime-slaking beds should have tight bottoms and strong sides, well braced to resist the pressure that will come upon them when they are full. A quantity of sand already screened should also be near at hand. Poorly screened sand later causes extra trouble and work. Gravel in the mortar delays workmen while plastering and floating, and much good plaster material will be lost in hurriedly throwing or picking out these gravel stones in the rush of applying the mortar on the wall.

The barrel lime is emptied into the upper box, and water is poured on while a workman breaks up the lumps and works the mass back and forth in various directions with a hoe. The thorough working of the material at this stage is necessary to ensure its complete slaking. The tendency of the careless workman is to hoe back and forth in the center of the bed without any regard as to whether he is stirring up the mortar that is down on the bottom boards, or whether the corners are drawn into the mixture and worked as evenly as the remainder of the box. If the paste is not thoroughly and evenly worked to an equal consistency throughout, if the water is not conducted to every particle of lime, or if the other ingredients are mixed in before the paste is

evenly prepared, the lime will be apt to *blister* and slake out unevenly, causing trouble after it is upon the wall. If the corners, for instance, are imperfectly mixed, lumps of clear lime will afterward appear. Many of these lumps will pass unnoticed under the hoe of the workman tempering the mortar, and will not be found until they are flattened out under the wall trowel of the plasterer.

If too much water is used in slaking the lime—especially if a too great amount is added at once—the pile is *chilled* and forms into lumps that slake too tardily. If too little water is added, the lime is left so dry (*burns,* as the plasterers call it) that many small particles entirely fail to slake through lack of sufficient moisture. When too much water *drowns* the lime in the first place, it becomes so thoroughly chilled that a considerable portion of its strength is lost; and the process of slaking is, by the very excess of water, much retarded. The process is also slowed up if very cold water is added, although the water soon becomes heated from the reaction of the lime. At the start, just enough water should be put on to initiate the slaking process. After this, as the slaking proceeds, more water should be added as needed, taking care to keep the lime thoroughly moist at all times. A very active and quick slaking lime should be covered with water from the very beginning, to guard against the possibility of burning. If the lime once *burns*, it will afterward be impossible, by any amount of working, to get out all the fine lumps that are then caused. Rich lime will afterwards work cool, is little likely to crack, and bears troweling when being finished, without the surface peeling off, blistering, or staining.

If lumps of unslaked lime escape through the screen when the lime is run off, and get mixed into the mortar, it becomes very difficult to eradicate them afterward. It is not possible for the plasterer to get these lumps out of the mortar when working it on the wall; and the results of their afterwards slaking out will continue to appear long after the house is finished. If they occur in the first coat, at various times after the work is completed—frequently extending throughout the entire first year—these lime lumps will suddenly *blow* or expand, forcing out the surface plastering outside them and making a large blister or lump, generally about an inch in diameter, which, if upon the ceiling, almost invariably falls off. If this unslaked lime gets into the final coat, much the same result occurs, although the particles

are of necessity smaller in size. Instead of being large, the resulting holes are then comparatively small, running generally about the size of the head of a pin, and the entire surface of the plastering is frequently pitted, the particles thrown off appearing about the room in the shape of a white dust.

In the brown rough-coat, the spots of white, unslaked lime are quite easy to see, as they are often the size of a bean or pea. However, in the final white coat, these spots, being smaller and of the same color as the rest of the mortar, do not show.

After it has once begun to warm up, the lime should be worked or stirred thoroughly during the process of slaking, so that, after the action has been completed, it will be of the consistency of a pasty cream. After slaking, the lime should be run off through a fine sieve (No. 5 screen) put at the end of the slaking box, into the next lower compartment, or mortar-bed. The screen is intended to keep out any lime lumps too large to slake before the mortar is used, or any flinty settlement that may be found in the lime, and to allow only a pure and thoroughly mixed hydrate to be admitted to the bed.

When drawing or running off the lime, a large supply of sand already screened should be at hand to scatter in the bottom of the mortar-bed and to use for stopping leaks that may appear as the box gradually fills. This screened sand should be sufficient in amount to complete the mortar mixture. An ample supply of water, either in barrels or in hose piped from a hydrant, should also be ready at hand—to avoid any possibility of the lime burning.

For the *putty* or *finish coat*, the paste should be made even thinner before running off, and may be of the consistency of milk. The sieve through which it is strained should also be finer, of about the mesh of an ordinary flour or meal screen. The paste for this coat is often obtained by running off the lime a second time, as by this means a cooler working putty is secured.

The length of time that mortar for plastering should be mixed before being used, is a much-discussed question. It is generally stated in architectural specifications, that "the mortar should be mixed ten days or two weeks before using." As a matter of fact, this requirement is not always either wise or desirable. It is true that, in old English work, lime mortar was left covered over with earth to stand for long periods of time, often six months to three years elapsing

before it was used. In this country, such slow-going methods are not to be expected. While lime does gain in strength by standing in this thin putty state before sand or other materials have been mixed with it, yet three or four weeks, at the least, are necessary before the increase becomes very apparent. It is also necessary that the paste should remain moist, by being kept covered all the time. At the end of the fourth month its strength will have increased about one-fifth, and most of this gain has been made during that month. From then on the gain continues, but gradually decreases in amount.

It is more economical for the plasterer to use a lime that has been slaked for some weeks, as, when tempered down, it will work freely with the admixture of a much larger proportion of sand than is taken up by lime mixed as soon as it can be readily worked. This extra amount of sand does not add to the strength of the mortar; but, as it causes the lime to cover a greater surface, it is a considerable economy for the contractor, made, however, at the expense of the quality of his work.

Lime mortar need be left standing only long enough for all its particles to be thoroughly slaked, and, if properly mixed and wet down in the first case, a great deal of time need not be required to effect that result. This once secured, the quicker the mortar is mixed and put upon the building, the better and stronger will be the plastering that is obtained. It is further claimed that the accompanying loss of limewater is also very harmful, as this water—from the properties which it has already absorbed from the lime—is much better suited for carrying on the process of mixing than newly added clean water. Yet, if the lime has been long standing, it may be necessary to add clean water to replace the water lost by evaporation or seepage, although mortar mixed with clean water never becomes so hard as that mixed with the water obtained in slaking the lime.

The sand and hair are next added, the hair being put in before the mortar becomes too stiff to work readily. After the sand is mixed, the mortar should not be left to stand for any length of time, as it would become considerably *set* and a loss of strength would result. If the mortar does become set in the bed, reworking would be necessary before it could be put upon the walls. The strength then lost bears a direct relation to the length of time it has stood, and the solidity it has attained, before this final working up.

In plastering mortar where hair is required, a still further loss of strength would result, as the hair would be so rotted or eaten by its long exposure to the action of the wet lime as to be almost or quite worthless. The hair cannot well be mixed evenly, except at the time when the mortar is first run off, while it is in a very thin paste. If, after a lime-and-sand mixture had been standing for some months, it were attempted to bring it to a sufficiently fluid state to receive the hair properly, by wetting it down a second time, a considerable proportion—varying from a quarter up to almost a half—of its strength would be sacrificed.

Bearing these facts in mind—once certain that the lime is slaked—it would appear better that not more than a week should elapse before the use of this mortar; and a less time than that is, under many circumstances, undoubtedly desirable. It is evident that no more lime-and-sand mortar should be mixed at one time than can be used within a few days at the most. The length of time that mortar should be allowed to stand, is determined more or less by the dryness or moisture of the atmosphere. The dryer the atmosphere, the shorter the time, as the setting of the mortar is, in part, a chemical result of the drying out, or evaporation, of the *water of crystallization*, as it is called.

It has already been said that limes made in different parts of the country vary extensively in their chemical composition and properties. A knowledge of the chemical composition of lime mortars and the individual peculiarities of the lime locally used, is necessary before applying or attempting to utilize the principles here set forth. In the eastern part of the United States, the limes frequently contain from a third to a half of carbonate of magnesia; and the mortar in which such limes are employed sets very readily.

To sum up, the lime should be slaked as evenly and thoroughly as possible. It should be run off from the slaking bed through a fine sieve into the mortar-bed It should lie there no longer than is absolutely necessary; and if it could be possible to add the hair and sand while the original mixture is sufficiently moist to take up and work the entire amount of the latter material to be added, the resulting mixture would undoubtedly be that much the stronger and more durable.

Mixing the Mortar. The amount of sand to be mixed in with the lime paste is a variable quantity, depending upon the sand itself,

upon the quality and thickness of the lime paste, and also upon the nature of the work for which the mortar is intended. With exceptionally rich limes, sand to the amount of about two times the bulk of the lime—measuring the slaked lime in the form of a rather firm paste—may be added. As will be seen, this is a most uncertain proportion, for a great deal depends upon the firmness of the lime paste alone. Allowing for variation in size of the lumps of lime and their closer or looser packing together, it may perhaps be better to say that the sand should bear a relation to the lime, before it is slaked, of from three to four and one-half times its bulk.

The richer the lime and the finer the particles of sand, the more of the latter should be employed, although the finer sand does not make as hard or as good mortar as the coarser variety. If both are clean and sharp, the finer and coarser varieties of sand may be mixed together with good results. Most laborers are apt to stop adding sand, merely because the mortar mixture becomes hard to work when the paste becomes too thick. This is poor policy, inasmuch as the mixture becomes much harder to work when the tempering is partly completed, a day or two later.

The fineness of the sand is an important factor. A rather coarse as well as sharp sand is considered best, as the amount and capacity of the voids left in such a mixture would be of such size as, without any doubt, would provide space to contain lime sufficient to cement this granular mass very firmly together. The close pressure and contact of the sand particles would also lessen the possibility of settlement or shrinkage, with accompanying *map-cracks*. The hair may be mixed in either before the adding of the sand or when but a very small proportion of the latter has been worked into the lime mixture. The hair is generally mixed with the mortar by means of an iron rake. It should be thoroughly mixed, and enough should be used to make it impossible to find any small sections of the mortar in which the hair cannot be seen. This will require from one and one-half to two bushels of hair to a cask of lime.

If the mortar is to be used as a first coat on stone, brick, or similar surfaces, it will carry more sand, and hair is not considered so essential. a half-bushel to the barrel of lime being generally ample. If too little sand is used, the plaster is liable to dry too quickly when setting, and, after it is dry, will crumble very easily, showing up too white, or ashy

gray, in appearance. If too much sand has been used, the plastering is liable to fall off, and will crumble when rubbed between the fingers.

Mortar for a second coat on lath may be of about this same consistency of mixture. For the final coat (the *putty* coat or *hard finish*) but very little sand is used. The harder the finish, the less the amount of sand. For this coat, the sand is mixed at the time when the putty is run off. For hard finish, when marble dust, brick dust, or anything of that sort is added, it is generally mixed together on the mortar-board immediately before applying. Stucco, or plaster of Paris, is never mixed with putty until immediately before using, on account of its rapid setting, which occurs in a few moments after mixing. When once set before being applied, it becomes useless. No more water than is necessary should be added, either in the mixing of the mortar at first or in its subsequent tempering, as over-much wetting of the lime deprives it of a considerable proportion of its strength, and also retards the setting process by giving that much more moisture that is necessary to be disposed of by evaporation or crystallization.

A bushel of lime is standardized to weigh 80 pounds; 200 pounds is allowed to the barrel; a bushel contains about one and one-quarter cubic feet. A barrel of sand is supposed to contain 3 cubic feet of sand, and a bushel of sand weighs about 120 pounds, and wet mortar 130 or 132 pounds. When hard, mortar is figured to weigh about 110 pounds to the cubic foot.

To summarize—one barrel of lime, 200 pounds, will take about a cubic yard of sand. In most localities a load of sand is supposed to contain twenty-seven cubic feet, or a cubic yard; but it is frequently less than this, extending down to two-thirds of the amount. To the barrel of lime should also be used about two barrels of water and—as we have seen—upwards of two bushels of hair for a first coat. Hair comes in paper bags weighing generally something under eight pounds and containing enough hair to beat up into a measured bushel. This amount of material, when the lime has been slaked and the whole mixed together, will amount to 35 or 40 yards (about 5 barrels) of mortar; and the amount should cover about 40 square yards of lathed area, requiring about 600 laths to surface.

The final skim coat is mixed roughly to the following proportions: A cask of lime to a half-tub of water, which should take up about a

barrel of the hard, clean sand used in the surface coat. Generally the plasterer uses a larger barrel or hogshead for water, than the cask in which the lime is delivered. Also, in some localities, the lime will run somewhat more than 200 pounds to the barrel, Maine lime from Rockland being supposed to average 220 pounds. Rockland lime is considered in the East good lime for scratch and brown coats, but many masons prefer Jacob's lime for the finish coat.

It should be remembered that the bulk of the completed mortar mixture does not equal the total combined bulk of its various ingredients, but is less than the aggregate bulk by about one-quarter.

PLASTERING

Interior plastering is now applied either in two or in three coatings. Three coats are always necessary on metal or wire lath, the first coat being required to stiffen the body of the material sufficiently to allow thorough working of the remaining coats. Even upon wood laths, three coats make a better job of plastering than two. Extra strength and body are obtained by the addition of the extra coat, provided time be allowed to dry out each of the coats thoroughly before the next coating is added. It has now, nevertheless, become the general custom to employ but two coats on the less expensive grades of residence work.

The plaster mortar is applied to the walls with a hand trowel of steel, about four and one-half inches wide by twelve inches long, having a wooden handle that is parallel with the back of the blade. After the mortar is put on and roughly smoothed out with the steel trowel, the *darby*, a long wooden trowel, about four inches wide and three feet in length, is taken by the workman and used—with a scouring motion—to level the plaster surface and work it to an even thickness and uniform density. The flat part of the darby is generally of hard pine, a half-inch or slightly more in thickness.

Three-Coat Work. The best interior plaster work always used to be put on in three coats, and was worked to a final thickness of about seven-eighths of an inch. Of the three coatings, the first is the thickest, so that, when dry, it may be strong enough to resist the pressure of working the coat or coats to follow. A large part of the advantage of three-coat plastering is obtained by thoroughly drying each coat out before applying another, thus securing the added dens-

ity and strength made possible by forcing the subsequent coating firmly and strongly against the surface upon which it is being placed. Rubbing or troweling up the rough mortar before it finally dries and sets, also makes it much more compact than is possible from working it at the time when it is first applied.

The first coat, called the *scratch coat*, contains the greatest proportion of hair, that being useful in strengthening the key or clinch of the plaster behind the edges of the wooden laths, through the crevices between which it has been forced. Before this coat thoroughly dries, the surface is *scratched* (hence its name) with a tool designed for that purpose. The surface of the second coat also is sometimes scratched with nails set into a wooden float or darby like that used to rub over the surface, before adding the finish coat. When one coat is entirely dried out before another is applied, this scratching is always necessary, the scratches forming a clinch or tie permitting the subsequent coat to unite the more firmly to the preceding.

The second coat generally contains a larger proportion of sand and much less hair than is necessary in the first coat. The surface of this second coat—or *brown coat*, as it is called—must be brought up true and even, especially at all angles, and be plumb upon the walls. Before the finishing coat is applied, lumps must be removed and all other imperfections corrected, and the mortar must become sufficiently set to allow the entire surface to be rubbed up with a float or darby and so made compact and firm.

To save time, the plasterer adopted the custom of putting his second coat on over the first while the latter was still green. The combined mass (practically one thick coat) was then darbied and treated the same as in two-coat work, over which about the only advantage of this method was in providing a rougher sand surface on the second coat than was possible when more hair (always necessary in first coat) was included. Otherwise, substantially the same results as are secured by thus working two coats together are obtained in the first coat of ordinary two-coat work, at a saving of both labor and time. While this method does not furnish so good or so permanent a job of plastering, it is modernly considered as meeting the requirements of three-coat work, when so specified.

The saving in this sort of three-coat plastering is made chiefly by the plasterer, in the expense of doing his work. The owner pays

more money than a two-coat job would cost him, and actually receives substantially the same grade of work. The second coat, too, dries more slowly when applied before the first coat is dry and hard, and there is therefore not so much saving in time as is generally believed. If three-coat work is attempted at all, it should be insisted that the first coat be thoroughly dry before the second is added.

The final coat is generally composed of lime putty, with a small proportion of white, clean sand, gauged with plaster of Paris. This gives the whitest finished surface. If a color is considered desirable, a colored sand may be used. All lath cracks or settlement cracks occurring in the previous coats should be cut out and patched before the last coat is applied. The final coat is about one-eighth of an inch thick, and the surface is burnished with the steel trowel to an even and straight surface, and worked sufficiently to free it from chip cracks or other surface defects. The lime for the white finish mortar should be run through a sieve of not less than ten meshes to the inch.

From thus combining the first two coats when green, the next step naturally, in the development of methods of work, was to apply but one coat, making it of increased thickness, and scratching it ready to receive the finish skim or white coat, except when it was desirable to finish the plaster with a rough surface, or to *sand-scour* it, as the last process is sometimes called.

Rough Plaster Finish. If the mortar is to be finished with a sand or rough finish, two coats are applied.

The second coat—which should be put on only after the first is thoroughly dry—is substantially the same as the brown coat described above, the rough finish being secured by working the surface of the second coat, before it dries, with a soft-faced float and a mixture of sand with some lime added. Sometimes the surface of the float is of carpet or felt, sometimes of cork or other soft wood. Only so large a surface as may be readily covered at one time, can be floated, darbied, etc., before it has time to set. In this case no hair whatsoever is put in the second coat, as the hair destroys the evenness of the surface that is obtained by the scouring action of the particles of sand rolling around between the surface of the float and the face of the plaster. A long float is generally used for scouring, and the surface is worked to an even and true face, care being taken not to leave any marks from the instrument itself.

While it is generally the custom to add rough plaster finish on the second coat, in inexpensive work, especially for summer residences, a very artistic effect can be obtained by rough-working the surface of the first coat. If one-coat finish is employed, hair must be used, and the consistency of the coat must remain much the same, whether it is surface-finished or not. In that case, however, it is not possible to work the surface as true and as even as the surface of a second coat.

Two-Coat Work. Most plaster work now consists of only two coats.

The brown mortar employed for the first coat should be made of fresh lime used as soon as it is stiff enough to be worked, with strong, well-distributed cattle hair and coarse, clean sand. The first coat of mortar must always be put on with sufficient pressure to force the plaster through between the laths, and so ensure a good clinch. The face of this coat must be made as true and even as possible on surfaces and angles, and plumb on the walls. After the first coat is sufficiently set, it may be worked again with a float consisting of a piece of hard pine about the size of the trowel. Sometimes the face of this float is covered with felt or other material to produce a rough textural treatment on the plaster surface. The first coat should run a strong five-eighths inch in thickness, and should be thoroughly dried out.

It is generally inadvisable to attempt to trowel a two-coat job very smoothly. If the attempt is made to float the first coat when it is too thin or insufficiently set, the instrument is likely to leave marks on the wall, and the plastering is itself likely to crack. It is better to err on the side of caution, as, if the plaster has become slightly too dry, it may easily be dampened by sprinkling water upon it with the plasterer's broad calcimine brush and following it immediately with the float. The use of water in this way has accompanying advantages in that it tends to harden the plastering and to prevent the hairs gathering along the edge of the float, when otherwise they would have to be shaken off every few moments to prevent their rolling under the instrument and being pressed into the surface of the plaster in tufts and rolls, in such a way as to show through even the finish coat.

Care should be taken to see that each coat invariably is absolutely dry and hard before the addition of another coat is attempted. Otherwise the later coat will fall off, in greater or less part, and it will be quite impossible ever to obtain a good surface finish; while, if it should

happen that the first coat is only partially dry when the second is applied, it will be seriously injured by the pressure brought upon it when floating. Its clinch to the lath is thus often partially or wholly broken, sometimes the plaster falling entirely off, leaving the laths exposed.

The finish second coat in two-coat work is the same as the final skim coat in three-coat work.

The Finish Coat. The *finish, skim*, or *white coat* should never be applied until the earlier coat or coats are thoroughly dry and hard, as it is liable to crack if put on before—quite aside from the possible danger of injuring the first-coat work by the pressure of troweling before it is entirely dry and set. A simple putty coat should carry more sand than when the finish is hardened by the addition of plaster. If plaster is used, the mortar should always be *gauged* (that is, plaster should be mixed with the putty) *after* it is placed on the mortar-board. The usual process of gauging consists in making a hollow with the trowel in the midst of the pile of lime putty lying upon the mortar-board. This hollow is filled with water, and the plaster sprinkled upon it, the whole then being mixed rapidly with the trowel and put upon the wall immediately, before the plaster has time to set. The proportion of lime and plaster, while variable, averages probably one-fourth to one-fifth plaster.

The finish is skimmed in a very thin coating that is generally less than one-eighth of an inch in thickness. It is immediately troweled several times, dampened with a wet brush, and thoroughly troweled to smooth up the surface and prevent it from chipping or cracking. The water prevents the steel trowel staining the surface, but the plaster should not be too wet, as it will then blister or peel. The whole surface of the finish coat, whether of putty or hard finish, should finally be brushed over once or twice with a wet brush; while, if a polished (or buffed) surface is required, it may be gained by brushing—without dipping the brush into the water—until a glossy surface is obtained.

Especial care should be taken, in the final coat, to finish all joints smoothly and evenly so that the point of jointure will not be apparent. The ceilings are completed first; then the upper part of the wall; and lastly the bottom portions which can be reached from the floor and thus more carefully finished up to the joint.

The plasterer generally scaffolds the room with boards at a sufficient height to enable him easily to reach the ceiling overhead without raising his arms too high to work each of the coats evenly. The plaster is applied on the upper part of the walls from the same scaffolding, and the remainder of the work is completed from the floor. If too much time elapses in joining the coats at this point, the joint is likely to show—which is, of course, not serious unless the walls are to be left untreated. Occasionally two men working along together, one on the scaffolding and one on the floor, finish the walls at the same time.

If the old-fashioned wooden angle-beads are used, the plaster should be neatly cut out from each side, forming a small V-sunk angle that prevents the thin edge running up against the corner-bead from breaking off. As a matter of fact. the use of a metal corner-bead makes a far truer, sharper, and straighter angle, and one that does not afterward tear or break the papering when it is put upon the wall. Angles in the plaster are generally finished with a wooden paddle.

As the hair is used principally to insure a clinch back of the lath, if plaster is applied on a stone or brick wall, a scratch coat is seldom necessary; and the coat of brown mortar is very often used without hair and of about the composition of brick mason's mortar. If a scratch coat is used under these conditions, it is generally mixed with more sand and less hair than when put upon laths.

For a finish where plaster mouldings are to be used, or when for any purpose an unusually straight, level, and plumb surface of plaster is required, three-coat work, put on in the old-fashioned manner, should be demanded. This is necessary in order to get a surface sufficiently level and true to run plaster mouldings evenly, and to avoid the inequalities that are almost certain to occur in all two-coat plastering.

The second and third coats allow opportunities to obtain a straight and level plaster surface. Individual spots are brought up to an even surface, the plaster then being added and carefully worked between and amongst them, bringing it all to the same face by means of the straight edge. Occasionally it happens that the rough coat is so uneven that some filling in is absolutely necessary to make the wall sufficiently even to receive the last coat. In that case, a mixture of half plaster and half putty may be used in leveling up the rough work.

If no finish coat is to be put on, the surface should be troweled smoothly as the mortar is applied, care being taken to leave no marks, hollows, or uneven places; but if the wall is to be finished or frescoed, it should be left with a floated surface.

Patent Plasters. Patent plasters, such as adamant, etc., are not often employed for private dwellings, being chiefly suitable for mercantile purposes. The patent plaster has certain advantages that are self-evident—such as quick drying and hardening. Its surface hardens more quickly and resists abrasure longer than the ordinary lime plastering However, a break once occurring, the extreme stiffness of the mixture makes it liable to extend further and to be of a more serious nature than if the softer, more flexible lime plaster covering had been injured in the same manner.

The extra stiffness of most patent plasters is caused by the cement that generally forms an important part of their composition. These plasters are sold ready for use, requiring merely the addition of a sufficient amount of water. They are therefore especially adapted for use by the inexperienced, and are valuable for executing small pieces of work, as they do not present the liabilities to failure, or loss of time and delay, occasioned by mixing up batches of lime mortar.

Back Plastering. Occasionally a wood-framed house is *back-plastered* for warmth. This process consists in nailing a strip of seven-eighths inch furring against the inside of the boarding on each side of the studs. The space between the studding is then lathed (of necessity a slow and bothersome job) and plastered one rough coat of hair mortar, which should be allowed to dry before any lathing is placed over it on the inside face of the studding. As a matter of practice, the efficiency of back plaster is much injured by the fact that the studding, in seasoning after the plaster is set, is likely to shrink away from the plaster, leaving a narrow perpendicular crack on each side of the stud, which permits of the passage of cold air.

Plaster Cracks. Cracks in plaster occur from several causes. If the distance between the ends of the laths, where they join on the studding or furring, is too great, the larger amount of plaster in that place, when drying out, may cause a short crack. Any such spaces should, however, be filled by the lather before plastering is begun. Sometimes, too, especially in the first coats, cracks are caused by the shrinkage or expansion of the wooden laths after the mortar has

wholly or partially set. The result is a series of narrow cracks parallel to each other and the width of the laths apart. *Lath cracks* are ordinarily filled in and covered up by later coats, and so do not often appear in the finished plastering. They may, too, be worked out when floating up the coat before it finally sets. If wide or deep, however, they should be cut out to a width of an inch or so, and filled in with new mortar before adding the last coat.

Cracks of a like appearance are sometimes caused by the rough mortar being too rich, or by draughts of air from open doors or windows drying out portions of the plastering too quickly. The too rapid drying of plaster with stoves or salamanders, often produces a like result from similar causes. An experienced plasterer should be able to determine the responsible cause and take measures accordingly, using more sand if the mortar is too rich, screening openings to prevent draughts, and using less fire in his drying stoves. In green work, damage already done may be repaired by refloating again before the work becomes too dry, softening the mortar with water if necessary.

Cracks sometimes occur in the angles at the ceiling or corners of the room. When in this location, they may be caused by the shrinkage or settlement of the partition or floor. In the perpendicular angles, especially, they may extend only to the depth of the finishing coats. In that case, the causes are likely to be either too thick plaster, insufficient troweling, or an insufficient amount of plaster in the gauged coat—causes which are easily remedied in the remainder of the work.

Cracks running diagonally across a partition, or radiating from the corners of doors and window openings, are caused by the unequal settlement or shrinkage of the building. They frequently occur at a perpendicular angle where a wood partition is brought up against a brick wall, or at the ceiling line where a wooden floor comes up against a brick supporting wall.

Cracks occur in the final finish when the putty is not gauged enough or not troweled or brushed enough, when it is put on too thick, and when too little sand has been used. These cracks are called *chipped cracks*. Plaster, when apparently perfect and without cracks, will sometimes crumble, either from too rapid drying or from the use of too much sand. Either too much or too little sand materially injures the strength of mortar.

If unclean sand, dirt, or clay has become mixed with the mortar, it not only weakens the lime but prevents its adhesion to the sand particles, so that no real set of the mortar ever occurs. Of course, at all times, poor materials—sand, lime, or hair—may be responsible for defects in plastering. Plaster occasionally falls off even when apparently hard and good, if the laths are too near together, if there is insufficient hair, if the mortar is too rich or too sandy, or if it had not been pressed against the laths with sufficient force when being applied; or it may become loosened by the springing of the laths under the pressure of floating it too hard. On brickwork the mortar requires considerable more sand than for application on laths.

Lime must have time to set before it dries out. Therefore, to last well, it should dry slowly. A stiffer working mortar makes better and harder plaster than thin or wet material, provided, of course, it is thin enough to clinch well to the lath in first-coat work, or to adhere to brick and dry scratched surfaces, and to spread evenly, in second-coat work. Stiffer mortar can safely be applied upon wet mortar than on dry; and wide-spaced lathing will take stiffer mortar than close-laid laths. When two coats of mortar have been put on, and the last coat falls from the first, it is generally because the first coat was not wholly dry when the second was applied. The coats must either be entirely dry or quite green to be successfully combined.

If possible, it is better to have the workman use makes of materials, especially lime, having those properties with which he is acquainted. Attention has already been called to the fact that different makes of lime vary considerably in their chemical composition. It is not even certain that lime of the same make will always run even in production, year after year. Of course, lime that has been slaked by exposure to air or water while in the barrel, and before it is used, is worthless. As this occasionally happens, it is well to be watchful and see that such bad material is never added to the plaster bed.

As a final warning, be certain that the last coat of plaster has dried out hard and strong before any wood finish is installed, as otherwise the wood will absorb the moisture from the plaster, causing it to swell and therefore opening cracks that are never likely afterward to be altogether closed. All wood finish should also be kept out of the house while plastering is going on, as it will absorb moisture from the air around it. The reason that sash are not ordinarily set until after

the plastering is finished, is because they absorb so much of the moisture as to cause the sash to swell in place. It is generally considered preferable to fill the window openings or doors with screens of cotton cloth, as this prevents direct draughts and still allows of a circulation of air that dries plastering much more rapidly than artificial heat, or than it would dry if these openings were closed by solid doors and glazed sash. In very bad weather the screen of cotton may be slightly strengthened, if necessary, by the application of a coat of whitewash on the inner side. Contrary to what might be supposed, the cloth window-screen is almost as good a protection against external cold and frost as is the glazed window, although the current of air passing through the cloth meshes of these screens into and out of the house, causes a slight loss of heat, adding somewhat to the expense for fuel required to dry out a plastered building. In good drying weather, these screens should be taken out and left out during the day, but should be replaced at night or in damp weather, when the plaster otherwise is likely to reabsorb moisture from the air and so delay the time of its final drying out.

If avoidable, the artificial drying of plaster by salamanders should not be employed; natural drying by sun and air is, under all circumstances, preferable. The salamander not only dries the room in which it is placed, too quickly—especially the ceiling above—but fills the air and the plaster itself with gas fumes, and, by steaming, is frequently the cause of the rotting of plaster or hair, thus reducing its vitality and life. Heating a house to dry out the plaster by means of the regularly installed heating plant, is preferable to the use of salamanders, the chief objection in this case being occasioned by the unduly rapid drying-out of wall plaster back of or above registers and radiators. The situation is helped if the radiator is set out from the wall and some screen is placed between it and the plaster. A screen may also be employed against the wall over a hot-air register; but there is no means of protecting the plaster on either side of a partition through which a hot-air or steam pipe passes. Such plaster is bound to be severely strained by being dried too quickly.

If plaster is frozen when wet, it is likely to loosen up and injure the whole mass so that it may eventually fall off. The effects of freezing are less troublesome if the wall is frozen after it is dried and has once set. If only slightly frosted, and thawed immediately and

floated again, it may often be saved, the effect in that case being not much different from what it would be if the wall had been surface-moistened and refloated.

Plaster Moulding. Plaster mouldings upon ceilings and walls are less frequently employed now than a few years ago, when, especially at the intersection of wall and ceiling, a heavy cornice of plaster was the common method of finish. Nowadays a cornice of wood is more commonly used.

Briefly described, the running of a moulded plaster cornice is as follows: Two parallel strips, or *screeds,* are run on the ceiling and the side wall, with their nearer edges evenly straightened. These edges are then fitted to the mould—a piece of metal cut out to a reversed section of the cornice outline. The mould is run along the strips fastened to the wall for guiding it, the lower edge being cut out and fitted to run upon them.

The plaster necessary to fill up the mouldings of the cornice may be tied back to the wall and ceiling by rows of nails driven so as to stand at about the location of its greatest thickness; while a strip of metal lath, filling in the angle upon projecting furrings, will offer the best possible clinch, and will help to reduce the thickness of the plaster and render its drying and shrinkage more equable and its surface less likely to crack.

When all is ready, enough putty and plaster are gauged in about equal parts to run the cornice down the length of one side of the room. The moulding form is then rested upon the supporting and guiding strip against the wall, and drawn along from right to left, pressed against the mass of mortar which is thrown into the angle just ahead of it by the trowel, the space immediately in front of the moulded strip being kept sufficiently full of plaster mortar to fill out the moulding entirely at all times. When the length is completed, or the gauged material is used up, the mould is moved back and forth along the length of cornice that has just been run, scraping away all the plaster except that included within the outline of the mould.

Where hollows occur, the gauged material scraped off by the mould should at once be thrown on again at these places, so that they may be immediately filled and brought up to the right section outline by again running the mould over these portions. The gauged putty will set in a few moments, and each side of the room or section of the

moulding must be run and completed or filled out very rapidly. The corners at the angles of the room may be filled in by hand, or a section of the mould may be separately run upon the floor, sawn in a mitre box, mitred and fitted in place upon the wall, the joint between the cast and run moulding being then carefully patched and evened off.

The extra amount of plaster included in the thickness of extreme projecting mouldings is the cause of occasional surface cracking; while other cracks are occasioned by the settlement, shrinkage, and movement of the house frame. For these and other reasons, it is now generally considered that a wooden cornice, despite its defects of shrinkage, is better suited than plaster to this purpose.

Finally, the moulding may be sprinkled with the brush and the mould may be run over it several times more, ending by finishing with a brush so as to give the moulding a gloss just as on the wall plastering. The same process is repeated for different kinds of plaster moulding, merely varying the method to provide for the different conditions set by circumstances, a circular moulding around the lighting outlet in the middle of the room, for instance, being swung from a peg driven into the center of the gas pipe or outlet box. Other kinds of plaster mouldings are run by unimportant variations of the processes described.

Cast ornaments are made separately in moulds, into which the plaster is poured. Most of these separate moulds are made of plaster hardened with glue or shellac, or surfaced with beeswax, and are generally oiled before being used. Plaster ornaments are fastened in place with fresh plaster or glue; occasionally a few screws are used, in which case the heads should be countersunk and covered in with plaster so as not to show.

EXTERIOR PLASTERING

Although exterior plaster surfacing for dwellings has been in use in Europe for many years, it has but recently met with favor in this country. In Italy, plaster, or stucco, applied in large, unbroken expanses upon a stone or brick building, has long been a favorite method of construction. Frequently, too, this plaster surface is stained or colored and worked up into different designs. In England, France, and Germany, plaster has been more frequently used in con-

nection with a half-timbered frame, although these countries also contain instances of its use in large, unbroken, simple surfaces.

In modern American work, it is not often that a brick wall is covered with plaster, as the æsthetic possibilities in the use of rough hard-burnt brickwork have now long been recognized; and when this—the cheapest brick-building material—is employed upon a dwelling, it is itself utilized for the exterior surface and to obtain the exterior effect of the structure.

Plaster has been used in this country in imitation timbered houses for some years; but recently its employment in large, simple surfaces, unbroken by the cross-barring strips of dark wood, has become popular —a treatment much more appropriate to this country. We also possess some examples of brick and stone houses, two hundred years old or thereabouts, that were covered and surfaced with white plastering; but in the most recent of American plastered dwellings, this effect has been simulated by applying the plaster to a wooden frame lathed with a fine-meshed wire cloth.

In any plastered building, the cornices should be projected sufficiently far to protect the walls and all exposed upper surfaces of the plastering. The farther this projection, the more certain the safety of the plaster, especially in the northern sections of the country.

The essentials for successfully-wearing exterior plaster applied in modern fashion, are: A well-seasoned, shrunk, and settled frame; a solid, immovable foundation; and a carefully applied and thoroughly worked job of plastering. The framework should be somewhat better constructed and more carefully arranged to prevent movement or settlement than on an all-wooden building. Other than this, the dwelling to be plastered outside does not differ, in any part, from the ordinary house, until the structure has been framed and boarded in. For plastering, the boarding is then covered with a slightly better and more waterproof grade of paper than if shingling or clapboarding were intended. Outside of this papering, the house is furred with strips of furring, seven-eighths of an inch thick by one and one-eighth to one and one-quarter inches wide (for metal lathing they are to be placed nine inches apart, for wood laths twelve inches, on centers), and the lathing is applied upon these strips.

METAL LATH

The best lath for exterior plastering is probably the No. 19 Clinton wire cloth. The wire is sufficiently large to be durable, and the mesh sufficiently open to allow the mortar to press through and completely fill and close in over the back of the wire, thus protecting it from exposure to the elements or damage from water and rust, even if the plaster surface should leak sufficiently to admit water behind this covering. Expanded metal is also used for this purpose, but it is not generally considered so good a material, from the fact that it is impossible to cover entirely and protect the back of this lath with plastering, and therefore there is no means of certainly protecting it from the possibility of rusting.

Occasionally, on a small, low house of not over a story and a-half of wall height, the boarding may be omitted altogether. The metal lath is then placed directly upon the furred studs, and plastered both outside and in to insure its absolute protection from damage by water. However, the shrinking of the studs opens a small crevice along each side—which has already been mentioned as occurring in back plastering—and it is thus possible that water may enter from the back and do considerable damage, even through the narrow space that this shrinkage provides. The omission of the outer boarding also somewhat injures the stiffness of the house, as a frame constructed in this way is not so well braced as when the boarding is applied. Neither are the dwellers in the house so completely protected from the exterior weather, as the second air-space obtained between the papering and the exterior plastering is lost. This extra air-space is of assistance in keeping the house more equably warm in winter and cool in summer.

In the use of metal lath, it is always to be remembered that the *absolute* essential is to protect the lath from the action of water and rust. This once done—in whatever fashion—a permanent and lasting plaster surface is ensured. Sometimes the metal lath is wired and fastened to perpendicular iron furrings of tee-irons or angles, held to the wood frame with staples or some similar fastening, allowing any possible movement of the frame to occur without affecting or straining the plaster surface, which is by this means disassociated from, while directly supported by, the house frame. Cracks around the windows and the angles of the buildings are thus prevented; but

it is a more expensive form of construction, and is not now employed except in the larger and more expensive residences.

From the use of wire lath, there are occasionally obtained small surface cracks, especially if the lath joint happens to come at a place where some strain is afterward placed upon it, and particularly where it is weakened from the movement of adjacent portions of the building. For instance, if a perpendicular lath lap is made on the line of the edge of the window finish, a crack on the line of this joint is almost certain to appear in the plaster, extending both above and below the wood-surrounded opening. Care should be taken to cut the strips of lathing so that the joint will come at least nine or ten inches on either side of the edge of the window or door finish. All furrings should also be kept away and back from all angles, internal or external, upon the walls, so that a certain clinch may be effected by the plastering at these important points.

WOOD LATH

Wood lath is occasionally used, and, in certain sections of the country, apparently with good results. It may be employed in two ways—one, in the ordinary manner, only spacing the laths somewhat further apart than would be advisable on the interior of the dwelling. The other method consists in laying the laths diagonally over the building in such a manner as to form a criss-cross lattice-work. In this case the distance between the laths is from three-quarters to seven-eighths of an inch, so as to allow the plaster to enter easily and form a solid clinch behind these lattice openings. The purpose of the diagonal criss-cross lattice is to provide more or less flexibility for the wall covering, so as to take up, without injuring or cracking the plastering, a certain amount of the movement that may always be expected in a wooden-framed dwelling. This method of employing lath, by the way, is in most localities almost as expensive as the use of wire or metal lath, which is probably a safer and surer material to employ. As large and as good a quality of heavy wood lath as can be secured, should be provided for exterior work. Lath cracks are also then to be expected, from the same reasons that apply to interior work; while the mortar should be somewhat softer and slower drying when used upon this material than when employed upon a metal surface.

If possible, it is advisable so to arrange the work upon the house that, after the completion of the frame, some time will still elapse

before the plaster is applied. If the frame can be boarded in, and the interior of the house plastered and finished under artificial heat during the winter, and the exterior plaster added in the spring, probably the best results are to be expected. Opportunity is then provided for the frame to shrink, settle, and contract. Most of the weight to be placed inside of the building is then also installed before the exterior surface is applied, so that much less strain and movement may be expected afterward to affect it than would be probable under the opposite conditions.

PUTTING ON THE PLASTER

Exterior plaster requires three-coat work. The first or scratch coat is indispensable when metal or wire lath is used, but almost equally important over wood lath. This first coat should be scratched or roughened while drying, and must be thoroughly dry before the second coat is applied. A greater time ought to elapse between the applications of exterior than of interior plaster coats, inasmuch as it then becomes possible to cut out many of the larger and more important cracks than have had time to appear, and to patch them before the second coat is put upon the house. The second or brown coat is then the less likely to crack; and, if a further extra time is allowed the plastering to dry, it can also be patched at the last moment before the final slap-dash or finishing coat is put upon the walls. This slower progress aids in giving a more permanent job and one that is at the same time less likely to give annoyance from surface cracks afterward making their appearance in the finish plastering.

The question of proportion in mixing the plaster is quite as variable here as in the case of interior plastering, and it is equally impossible to give absolutely definite directions. Different plasterers, each being guided by the experience obtained from working in different sections of the country, prefer their individually different ways of proportioning or mixing their materials. In the first coat, cement is added to the lime mortar in proportions varying between ten and forty per cent of the mixture. Some plasterers prefer that the first coat should be less stiffened with cement than the second. With others the reverse is true; while, contrary to the general supposition, the exterior coat appears—in the majority of cases—to contain only that amount of cement necessary to provide the tone or color that is desired

for the exterior treatment. Conditions also greatly affect these proportions. When the plaster is added last on a well-seasoned and shrunk frame, for instance, it is worked stiffer than when the building is newer and still far from finished.

The final coat for exterior plaster is generally applied as a *slap-dash* finish, the surface texture being given by the throwing of handfuls of variously sized pebbles or gravel upon the fresh outer coat, thus pitting or marking up its surface. The smaller the size of the particles employed for this purpose, the more likely they are to stick and remain in the fresh putty, slightly tinting the surface with the color—if any—of the gravel employed.

The coloring of exterior plastering is done in much the same way as when it is used inside the dwelling. As a rule, it may be said that not sufficient consideration is bestowed in this country upon the possibilities provided by the use of color for exterior plaster work.

It is agreed that the utmost care to prevent absolutely any leakage is necessary on the part of the workman in the carrying out of this class of work; and it is here that the success or failure of exterior plastering most often hinges. Of course, the joints occasioned by the juxtaposition of the wood finish and plaster around window and door openings offer many opportunities for leakage. The plaster should here be carefully flashed; and, if possible, an outer architrave backband should afterward be put on so as to cover and protect this joint. Otherwise, a key should be provided for the plastering, by cutting away or hollowing out a space near the inner edge of the wood façure, into which the plaster may be pressed by the workman, and leakage thus prevented even if the wood, as is quite likely, shrinks slightly away from the plaster after it has been put in place.

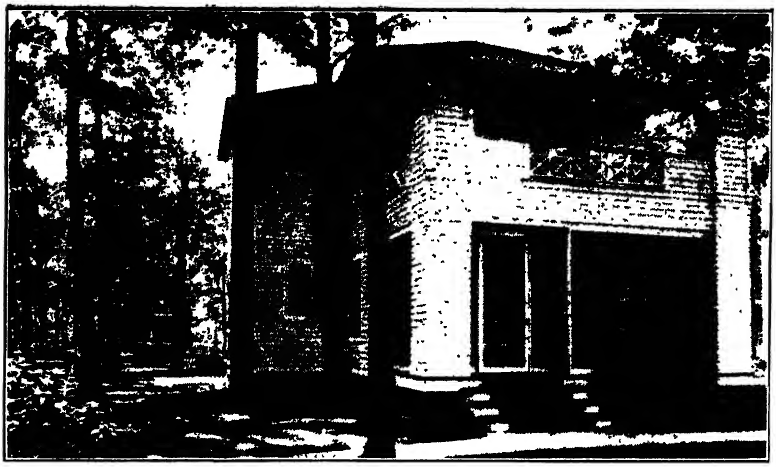
The problem of making tight this exterior plaster wall is complicated and rendered more difficult when it is divided into panels by a so-called *half-timber* treatment. In this style of design, a great number of joints between plaster and wood are occasioned where the wide wood boards are almost certain to shrink away from the plastering, and where, too, it is impossible to protect these joints by outer applied battens in any way capable of covering such an opening as may occur. Thorough flashing on all upper exposed surfaces, assisted by protecting overhang of the roof eaves, and broad keys provided for the entrance of

the plaster at all perpendicular and lower horizontal joints, must alone be relied upon.

Under no circumstances, so far as the lasting value of the work is concerned, does the mixture play so important a part as the expending of great care upon the thorough surfacing, working, and finishing of the mortar, pressing it into every crevice provided to receive it, flashing thoroughly every exposed or upper surface provided by the finish, and taking every precaution to work out all pinholes or other defects where water could possibly penetrate the surface. Every care and endeavor is directed to providing a solid, evenly worked, and permanent coating which will, in every possible way, throw off and prevent moisture being admitted into the space back of the plaster coating—that vulnerable portion where its attack is most effectually concealed and most to be dreaded.

The exterior plaster treatment of a cement or concrete wall is a problem that from now on will continue to be of rapidly increasing importance. Here, however, it is but necessary to use the cement as nearly *neat* as possible, adding lime or a make of white cement in case a brighter surface color is desirable. The problem of the æsthetic treatment of concrete construction is one that requires separate and particular consideration. Its solution has, as yet, been hardly attempted. Hollow terra-cotta tile is another material that is being modernly used more and more as a structural base to take an exterior plaster surface finish.

The student desiring to obtain a wider knowledge of the intricate subject of exterior plastering, may be referred to several articles published in the 1907 numbers of *The Architectural Review*, Boston. For a work treating historically and practically of the entire art and craft of plastering—within and without the dwelling—see Mr. William Millar's treatise "Plaster, Plain and Decorative." It would be as well to remember, in consulting the latter volume, that it was issued in 1897, and that the subject is treated from the point of view of an English workman, accustomed to methods and materials somewhat different from those common in American practice.



EXTERIORS AND INTERIOR OF HOUSE SHOWN IN PLAN ON PAGE 399

PAINTING

Introductory. The first thing a man wishes to know when he contemplates painting a house, is the *cost*. This will obviously depend on the cost of labor, of materials, and the kind of materials chosen. The outside of a house is painted, either in whole or in part; the interior may be painted or varnished. Some houses have their walls partly covered with shingles; these shingles are sometimes painted, and sometimes—in fact, often—left unpainted; but what is called the *trim*—that is, the boarding about the eaves, windows, doors, the base-board, and corner-pieces—is painted. Shingles, either wall or roof, are often stained with a creosote stain consisting of a coloring matter dissolved or suspended in a liquid called *creosote*, which is applied for the purpose of preserving them; and though instances can be cited in which wall-shingles that were never stained are still doing good service although believed to be now two hundred and fifty years old, yet the use of creosote will undoubtedly prolong the life of modern, sawn shingles, as it is noxious to insect life and a powerful deterrent of natural decay. The color of unpainted new shingles is generally disliked; but after four or five years wall-shingles take on a beautiful, soft color. The question of staining shingles is a matter of taste.

Most houses are exteriorly painted with paint based on white lead or zinc. Some idea of the cost may perhaps be gained from the following considerations:

White lead is sold either ground with a little oil to a thick paste, or—less commonly—in the dry state.

A mixture of 100 pounds of paste white lead with 5 gallons of linseed oil, makes $6\frac{1}{2}$ gallons of paint, weighing 21.3 lbs. per gal.

Approximate figures are: 15 lbs. paste lead and 6.3 lbs. oil equals 1 gal. (1 gal. oil equals 7.7 lbs.); 14 lbs. dry lead and $7\frac{1}{4}$ lbs. oil equals 1 gal.

A mixture of 100 pounds of white zinc and $8\frac{1}{3}$ gal. oil, makes $10\frac{5}{6}$ gal. of paint; 12 lbs. zinc and 1 gal. oil make 1.3 gal., or 9.5 lbs. zinc and 5.7 lbs. oil make 1 gal. white zinc paint weighing 15.2 lbs. Dark-colored paints made from iron oxides, ochers, and the like, weigh 12 to 14 pounds per gallon; but exact figures cannot be given, as the raw materials differ greatly.

Here should be noted the difference between the priming coat and the succeeding ones. A *priming coat* is the first coat applied to the

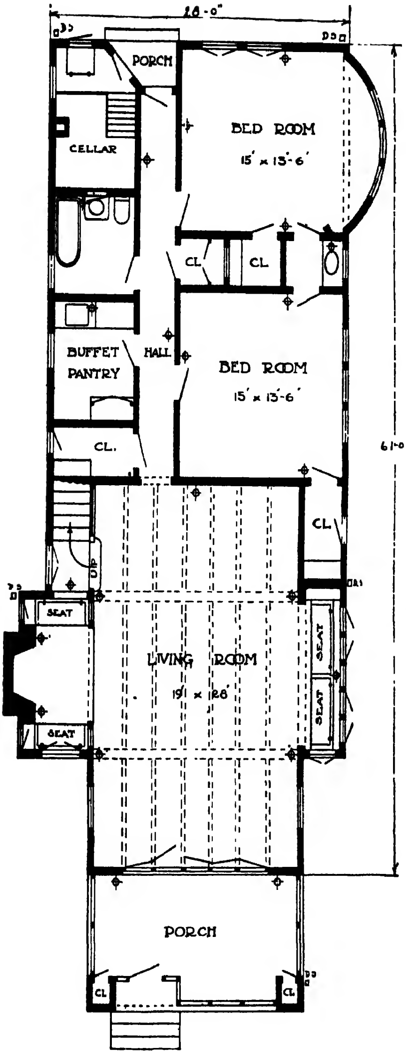
clean wooden surface; it differs from the other coats in containing more oil, because the wood will soak up the oil and leave the coloring matter of the paint on the outside.

To make the paint for the priming coat, take a gallon of the paint already described and mix with it a gallon of raw linseed oil. Paint thus made is, of course, lower in price; it is also much thinner; but such is the absorbent power of the wood, that the priming paint does not cover as much surface as the succeeding coats per gallon. A gallon of this thin priming coat covers 300 to 400 sq. ft., while a gallon of second or third-coat paint, well brushed out, will cover about twice this surface; this is because the surface for all but the first coat is hard and non-absorbent. Priming coats are used for both outside and inside work, as will be described later.

The dark-colored paints are usually cheaper than those made from lead and zinc, and if made of good materials are not inferior in durability; the extraordinary claims made by the zinc and lead manufacturers are to be received with much doubt. Some of the dark-colored paints are the most durable that can be applied on wood. The chief cost of painting is, however, that of labor, which varies according to locality and other conditions, seldom being less than twice that of materials.

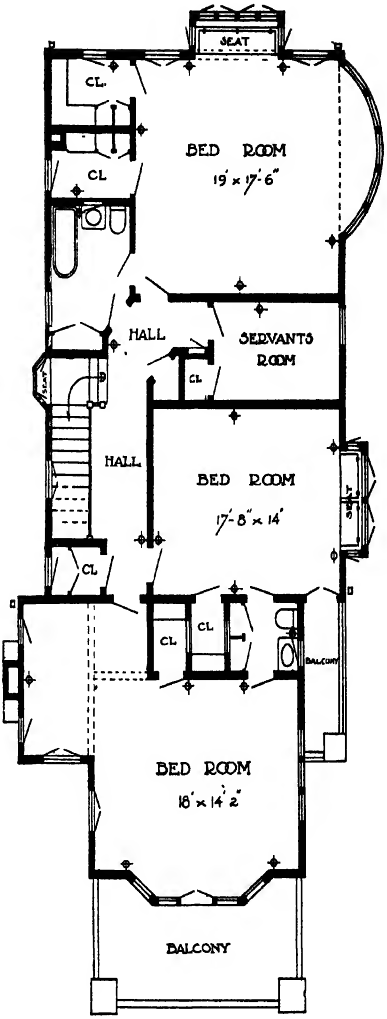
For light-colored paints, it is better to use raw linseed oil to which pale japan dryer may be added, as described later; for dark colors, either this or boiled oil, boiled oil being darker in color. The cost is practically the same; also the durability.

On inside work may be used either oil or enamel paint, as described later, the former being the cheaper, the latter the handsomer and slightly more durable; or the wood may be finished in its natural color, by varnishing it either with an oleo-resinous varnish or with shellac varnish. The oleo-resinous varnishes darken the wood very appreciably, while white shellac varnish keeps it more nearly in its natural color; although the latter does not prevent the natural darkening action of light, it may retard it. Shellac varnish is the more expensive finish of the two, if well applied. What is sometimes called *oil finish* generally consists in the application of a cheap varnish called *hard oil*, which is usually made of common rosin, linseed oil, and benzine. Its only merit is that it is cheap.



FIRST FLOOR PLAN

SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 FEET



SECOND FLOOR PLAN

SCALE 0 1 2 3 4 5 6 7 8 9 10 11 12 FEET

SUMMER HOME OF DR. J. B. McFATRICH, LAKE GENEVA, WIS.

W. Carbys Zimmerman, Architect, Chicago, Ill.

Frame House Built in 1906. Plan is Conditioned by Narrowness of Lot Overlooking the Lake The Interesting Feature is the Screened-in Porch, which, by a Series of Folding Doors, can be Made Part of the Living Room. The High Frieze in the Living Room is Decorated with Woodland Scenes Showing the Lake and Hills in the Distance. Exterior and Interior Views Shown on Page 396.

It would indeed be possible to apply neither paint nor varnish, but merely to saturate the wood with oil, and this would be truly an oil finish; it would, however, make the wood dark and dingy, and would readily retain dirt, and is a practice seldom followed except sometimes on floors—especially kitchen floors—and sink shelves. These are at frequent intervals oiled with a mixture of equal parts boiled oil and turpentine.

It is the purpose of this Instruction Paper to describe only good and approved methods. It will readily be understood, and will certainly be observed in practice, that these methods may be abbreviated by the omission of some details that are here specified as desirable. For instance, it is difficult to get interior finish sandpapered or rubbed between coats, even if so contracted; but this is the right practice. Two coats of varnish often have to serve in the place of four. No one, however, needs to be told these things. The methods herein described are not luxurious or extravagant; they are, on fairly good houses, truly economical; and we are not considering temporary structures.

It is not uncommon to find part of a house, as the living rooms, finished in varnish, and the kitchen and pantry painted with oil paints, which are lighter in color and more easily renewed. The sleeping rooms, on the other hand, are often finished in enamel paints, because color effects are desired to harmonize with the furnishings; and bathrooms are almost always done in enamel for sanitary considerations. The taste and inclination of the owner are to be consulted in regard to all these matters.

PAINTERS' SUPPLIES

Pigments and Vehicles. Paint is a mixture of a finely-divided solid substance with a liquid which, when spread on a solid surface with a brush or otherwise, will adhere and in a short time form—by evaporation, or more commonly by oxidation—a somewhat hard and tough film. The finely divided solid is called the *pigment;* the liquid part, the *vehicle.* The most common vehicle is *linseed oil.* This is an oil obtained by pressure (or extraction by solvents) from flaxseed. When spread out in a film and exposed to the air, linseed oil is converted into a tough, leathery, elastic substance called *linoxin,* insoluble in water and all common solvents. This change is brought about by

absorption and chemical union of the oxygen of the air, whereby the weight of the oil is increased about one-fifth or one-sixth. It is therefore a mistake to suppose that oil paint gets dry as whitewash does, by the evaporation of the liquid. Instead of that, it gets heavier. There are some other vegetable oils which have this property in some degree, but none which are used for paints to any considerable extent; some are used a little for artists' colors.

Linseed oil should stand at least a month or two before using. It should then be perfectly free from sediment or cloudiness; if it is not so, this is a sign that the oil has not been properly aged, and such oil is not fit for making paints. In this natural state, it is called *raw oil;* and the price of linseed oil as commonly quoted refers to raw oil. *Boiled oil* is this raw oil which has been heated, usually to 450° or 500° F., with the addition of a small amount of oxide of lead or oxide of manganese, or a mixture of the two (occasionally some other lead or manganese compounds are used). Boiled oil is darker (browner) in color than raw oil, but differs from it chiefly in that it dries five to ten times as rapidly. A thin film of raw oil on a glass or metal surface will dry at ordinary temperatures in five or six days, so as to feel no longer greasy; but boiled oil will do the same in a day or half a day. Oil dries best in warm, dry weather and out of doors.

The pigment is mixed with the oil by stirring the two together. This is usually done by power, in a vessel called a *paint mixer.* The mixture should then be run through a *paint mill;* some paint mills are of steel, but the best have a pair of mill-stones, between which the paint is ground and most thoroughly mixed. Paints mixed in this manner are much better than those which are mixed only by stirring.

Besides oil and pigment, paint sometimes contains a volatile *thinner,* the most important thinners being *turpentine* and *benzine.* Turpentine is a well-known essential oil, volatile, boiling at about 320° F., but evaporating at ordinary temperatures when exposed to the air. Benzine is a mineral oil, lighter than kerosene and heavier than gasoline; the kind used in paint and varnish is called "62-degree benzine," its specific gravity being 62° on the Baumé scale for liquids lighter than water. Linseed oil weighs 7.7 lbs. per gallon; turpentine, 7.2 lbs.; and 62° benzine, 6.1 lbs. But linseed oil is sold by the oil makers and dealers on the basis of 7.5 lbs. per gallon.

A dryer, in some form, is an essential ingredient of oil paint. A *dryer* is a compound of lead or manganese (generally both), soluble in oil, and is usually sold, under the name of *paint dryer* or *paint japan,* as a solution of such material in a mixture of oil, turpentine, and benzine. It is usually of such strength that an addition of from 5 to 10 per cent of it to a raw-oil paint will make it dry in from six to twelve hours sufficiently to be carefully handled. Paints are not dry enough to use, until they have stood four times as long as this; and they continue to harden for months. The strongest drying japans are dark in color; but such are more injurious to the durability of the paint than those which are paler, especially if the latter do not contain rosin. The buyer should always ask for a guarantee that the dryer is free from rosin, if great durability in the paint is needed. Not more than 10 per cent of any dryer or japan should ever be used in any paint. Slowly drying paints are more durable than quick ones.

In house painting, the white pigments are the most important, because they are the base of all light-colored paints. The most important white pigment is *white lead.* This is sold either as a dry powder, or (more commonly) as paste white lead, which is made of 90 lbs. dry white lead and 10 lbs. linseed oil. This can be thinned with boiled oil to make a white paint. White lead is a very heavy pigment; and with a given quantity of oil, more of it can be mixed than of any other pigment, except red lead. It has great opacity, or covering power. It is discolored by gases containing sulphur, becoming brown or black; and unless exposed to fairly strong light, it becomes yellowish even in pure air. It is better if it has been mixed with the oil for some time—a year or more.

White zinc is a somewhat purer white than white lead; not so opaque. Three coats of lead are reckoned equal to five coats of zinc. It becomes harder than lead, but is somewhat liable to peel off; while lead, after exposure to the air for a long time, becomes dry and powdery on its surface, and *chalks.*

A mixture of two parts of lead and one of zinc is much liked. *Zinc-lead,* however, is the name of an entirely different pigment, made by furnacing ores containing about equal parts of lead and zinc, in which the lead is present as a sulphate. This pigment is free from the liability to turn brown if exposed to sulphur gases; it is said to be not quite so pure a white as the preceding. It is a comparatively new

pigment, but is coming rapidly into use, being somewhat cheaper than the others. *Lithopone* is another white pigment of considerable merit.

Adulterants. All these pigments may be *adulterated* with barytes, or with *terra alba* (sulphate of lime), sometimes with whiting (carbonate of lime). These adulterants are powdered minerals. Barytes is a good pigment, so far as protective action goes; and terra alba is thought by some good authorities to be unobjectionable; but whiting is injurious. All of them are transparent in oil, and lessen the opacity or whitening power of the paint.

From these white paints, *colored paints* are made by adding *tinting colors*, of which the yellow is chiefly *chrome yellow*, or chromate of lead; the blue may be either *ultramarine* or *prussian blue*; and the green is *chrome green*, a mixture of chrome yellow and prussian blue. The reds are (in house paints) made from *coal-tar colors*, and most of them are now fairly fast to light. Some dull yellow colors are made from *ochers*, which are clays tinted with iron oxides, roasted and ground. These are permanent colors.

The dark-colored paints may not contain lead or zinc at all. The deep yellows, greens, and blues are made from the colors already named as tinting colors, none of which are entirely fast to light; the dark reds and browns are chiefly *iron oxides*, which are a valuable class of paints, very permanent on wood. The blacks are either *lamp-black* or *drop-black* (bone-black) and other carbon colors; and these are often added in small quantity to secure some desired tone or shade of color.

The zinc and lead pigments have some action on oil, and in their case it is considered the best practice to apply thin coats; but the dark pigments do not act on oil, and, of these, thick coats are best for durability.

Paint and Varnish Brushes. A brush that has only a low price to recommend it will prove a poor investment. If properly cared for, brushes last a long time, and it pays to have good ones. The first sign of a good brush is uniform quality from outside to center. Inferior brushes have inferior bristles in the middle, and some poor brushes are actually hollow. For ordinary oil painting, the bristles on a large new brush should be five or six inches long, uniformly flexible, and as stiff as can be found; they will be flexible enough anyway, but all should be alike.

Paint brushes are *round, flat,* or *oval.* A favorite brush for ordinary outside work is what is called a *pound brush,* a large, round brush with stiff bristles six inches long. Such a brush should be *bridled* when it is new—a "bridle" being a piece of cord wound around the bristles to shorten their effective length; as the bristles become worn off, the bridle may be removed. A 2½-inch oval brush (2½ inches wide) is a highly satisfactory tool to use in general painting, and is the brush recommended by the paint committee of the American Society for Testing Materials. It is worth noting that this committee, made up equally of expert paint manufacturers and experts employed by the large consumers, unanimously agreed that no larger brush than this should be used in making paint tests.

The use of brushes five inches wide is common for outside work; but while such brushes may be had of the best quality, they are heavy and laborious to use, and the workman who uses such a brush will not brush the paint sufficiently to get the best result. If a flat brush is used, it should not exceed 3½ inches in width; and three inches is better. A good 2½-inch oval varnish brush is a most excellent brush for all large work in either paint or varnish. The painter should also have a good 1½-inch oval brush for smaller work, and a number of round or oval brushes, called *sash tools,* of different smaller sizes, for more delicate work, such as sash and frame painting. Stiff-bristle brushes, which have been worn off short, are suitable for such work as rubbing-in filling. For varnishing large surfaces, flat bristle brushes 2½ inches wide are good; also similar ones 2 inches, 1½ inches, and 1 inch wide are useful. All flat brushes should have chiseled edges. For flowing varnish, it is necessary to have thick, flat, camel's-hair brushes, running up to 3½ inches in width, although most house varnishing may be done with brushes not over 2½ inches wide.

Besides paint brushes, the workman will need some ordinary *scrubbing brushes* and one or two painter's *dusting brushes,* to have the surface properly cleaned.

Steel-wire brushes, with stiff steel wire instead of bristles, shaped like scrubbing brushes, are used for cleaning off old paint and for cleaning structural metal work. These are of various sizes; and the steel wires are of different lengths and sizes, hence differing in stiffness. They may be had at hardware stores.

Care of Brushes Hair and bristle brushes must be kept clean

and soft; this can be done by care and faithfulness. They should not be allowed to become dry with paint or varnish in them. To prevent this, wash them out in oil or turpentine as soon as you are through using them; or they may be left in the paint or varnish for a few days. They may be kept over night by wrapping them very closely in paper if they have been used in a slow-drying material; in this way they may be carried from one place to another. Brushes should not be left to dry with even clean oil or turpentine in them; if they are to be put away, they should be well washed first with soap and water, then with clean water, then hung up until thoroughly dry.

In use, brushes are best kept in what is called a *brush safe*. A deep wooden pail, with nails driven in its sides at different distances from the bottom, and with a close cover, makes a good receptacle for brushes. The brushes have holes in their handles, or loops of cord tied to them, and are hung on these nails; their bristles dip into some turpentine or oil in the bottom of the pail; they are so hung that they do not dip into the liquid above where the bristles project from the binding. If brushes are left standing on the bristles on the bottom of a vessel, they soon become one-sided and distorted in shape. Tin brush-safes may be bought of any large dealer in brushes.

A brush which has dried with paint or varnish in it, may be recovered by soaking it in a non-alkaline varnish-remover. This will in time soften it so that it may be used again, but it is not improved by such treatment. Brushes used in shellac should be washed out with alcohol instead of turpentine or benzine. No brush is good unless it is clean.

Fillers. Fillers are of two kinds—*paste* and *liquid*. Paste fillers are something like a very thick paint, and are composed of some solid powdered substance, usually silica or powdered quartz, mixed with a quick-drying varnish thinned with turpentine or benzine. This is applied to the dry surface of the wood with a stiff, short-bristle brush, or is put on with a clean, white cotton cloth, and well rubbed into the pores of the wood. After half an hour or so, the surface of the wood is wiped off with a wad of excelsior or a clean cloth or a piece of felt. A liquid filler is a quick-drying varnish; and most of the liquid fillers on the market are cheap rosin varnishes loaded with dryers, and should never be used. Paste fillers are the best in almost all cases.

HOUSE PAINTING

Inside Work. All window and door frames, whether they are to be finished with paint or varnish, should receive a good coat of paint made with some cheap pigment, such as iron oxide, and boiled oil, applied to the back of the frame, before they are brought from the shop to the house; this prevents the absorption of moisture and hinders decay. If they are to be painted, they should receive a priming coat in the shop, if possible; if not, it should be applied as soon as practicable. The priming coat is composed of white lead and boiled oil or raw oil, with five to ten per cent of dryer; and should be almost all oil, with very little pigment. Turpentine is not a good thing in a priming coat, because the object is to fill the pores of the wood, and turpentine evaporates. As soon as this is dry to the touch, all holes are to be filled with putty. The best putty for this purpose is white lead putty, made by mixing a little raw oil with dry white lead, or by adding dry lead to paste lead until it is of the right consistency. This kind of putty hardens quickly as compared with common putty, and is the best for this purpose. A steel putty-knife should not be used on interior woodwork, as it is almost certain to scratch it; a hardwood stick, suitably shaped, should be used. All cracks, joints, and nail-holes should be carefully filled. All knots and sappy places should be varnished with shellac varnish; this prevents the pitch and moisture from attacking the paint. The shellac should be applied where it is needed, before the priming coat. The priming coat should be given time to get quite dry; at least a day—two days, if possible; and a week is better yet. Then it is ready for the second coat. This should contain a considerable amount of turpentine. If no turpentine is used, the surface is likely to be glossy, and the next coat of paint will not adhere well; but by replacing part of the oil with turpentine, we get what painters call a *flat coat*—that is, one which is not glossy; if this is made from paste lead or any paste paint, it can be produced by thinning the paste with a mixture of oil and turpentine in equal proportions; some painters prefer one-third oil and two-thirds turpentine. This is for inside work only. This coat should be allowed to dry thoroughly; if it takes ten hours for the paint to be dry enough to handle, then at least four times ten hours *additional* should elapse before the next coat is applied; this is a good general rule; and as much more time as possible should be allowed. If the finish

is to be ordinary oil paint, the next coat may be paint, thinned with about half as much turpentine as before, or with no turpentine at all. In the latter case, when the coat is thoroughly dry, it must be carefully examined, and, if glossy, it should be rubbed with something to take off the gloss; curled hair is often used, or a light rubbing with pumice and water. Then the final coat, which has no turpentine in it, may be applied.

But if the finish is to be with an enamel paint, the second coat, when quite dry, should be very lightly sandpapered with fine sandpaper, and the third coat should be of like composition to the second, treated the same way; then the enamel paint is applied. For a really first-class job, when this is quite dry, it should be rubbed down with curled hair or pumice and water, and another coat of enamel put on. This may be left with the natural gloss if desired; or it may be rubbed with pumice and water to a flat (dull) surface.

Painting Plastered Walls. Old plastered walls may be painted with oil or enamel paints as though they were wood, remembering that the priming coat will have almost all of its oil absorbed by the plaster. New plastered walls do not take paint well, on account of their alkaline character, which gradually disappears with exposure to the atmosphere. It is well to let a wall remain unpainted at least a year. But if it is necessary to paint a freshly plastered wall, the wall is prepared by some painters by washing it with a solution of sugar in vinegar, the sugar uniting with the lime to some extent; or—more commonly—by washing it first with a strong solution of common alum and then with a solution of soap. After this is dry, it is washed with clean water, allowed to dry, and then painted. The alum and soap form an insoluble compound which closes the pores of the plaster to some extent, and prevents the lime from acting on the paint.

Outside Work. Exterior paints are more elastic, as they need to be far more lasting, than those used on interiors, since the effect of exposure to the sun and rain destroys paint more than almost anything else does. Paint on the interior of a house will last almost indefinitely; but on the outside the best paint is not very durable. The surface, if new, should be cleaned by brushing; knots should be shellacked; after which the priming coat should be applied. This may be the same paint which is selected for the finish, only thinned with boiled oil (or raw oil and dryer), using one to one and a-third

gallons of oil to each gallon of paint. The reason why ordinary paint may not be used as a primer, is that the wood absorbs the oil, leaving the pigment as a comparatively non-adhesive powder on the surface, from which the next coat will probably peel off. The next step is to putty up all nailholes and other defects. For the second coat, many experts advise the addition of half a pint of turpentine to the gallon of paint; others make no addition to it. The third coat is applied after the second is thoroughly dry; if a week or a month can elapse between these coats, so much the better.

Repainting. If the old paint has been on a long time, it is liable to be permeated by minute cracks, which admit moisture to the surface of the wood and loosen the paint. If now we paint over this, the new paint, which shrinks in drying, tends to pull off the old paint, and of course the whole peels off in patches. If the old paint is in this state, it must be removed before the new paint is applied. This can be done by *burning off*. For this work a *painter's torch* is required, which is a lamp burning alcohol, gasoline, or kerosene, and is so constructed that a blast of flame can be directed against the surface. This melts or softens the old paint, which is then immediately scraped off with a steel scraper. The paint is not literally burned, but is softened by heat so that it can be scraped off. In some cases it is sufficient to remove as much as possible with a steel brush; this is a brush like a scrubbing brush, with steel wires instead of bristles, and, when vigorously used, will take off the loose paint.

Old paint, however, is not always in this condition. If it adheres well, it may be cleaned with an ordinary scrubbing brush and water, and when it is quite dry, the new paint may be applied. Sometimes the paint seems in good condition, only it has faded and lost its luster; in such cases a coat of boiled oil, or raw oil with dryer, is all that is needed.

It is well to paint the trim—that is, the window-casings, door-casings, corner-pieces, and the like—before painting the body of the house; then the paint can be applied to the flat surfaces more neatly than is otherwise likely to be done. Paint should be applied in thin coats, well brushed on; it is not unusual to see paint come off from re-entrant angles while it is still good on flat surfaces, because it was difficult to brush the paint properly in those places. There is a great difference in durability between a thin paint flowed on with a large,

flat brush, and one of proper consistency well brushed out with a brush of medium size. In all painting on wood, it is desirable to brush it on with the grain of the wood; and by painting only a few boards at once, we may avoid laps by painting the whole length. Rough surfaces hold paint better, and more of it, than smooth. A gallon of paint will cover, one coat (on a painted or well-primed surface), about 600 square feet, not flowed on, but well brushed out in a thin film. The priming coat will not cover more than 300 or 400 square feet to the gallon. In measuring the outside of a house for surface, make no deductions for doors and windows; if the trim is to be painted a different color, from one-sixth to one-third of the paint will be required of that color. Paint should be stirred frequently while using. A coat of dry paint is from $\frac{1}{500}$ to $\frac{1}{1,000}$ of an inch in thickness.

Roof Painting. Roof paints should contain a larger proportion of oil to pigment than other paints, and less dryer (or none at all). Many think that the addition of ten to twenty per cent of fish oil to a paint for roofs is advantageous; fish oil greatly retards drying and prevents the paint from becoming brittle. Tin roofs, if new, should be thoroughly scrubbed with soap and water, or with pieces of harsh cloth, such as burlap, well wet with benzine. They may then be painted.

Paint dries relatively fast on roofs; but as a roof paint is very slow-drying, plenty of time must be allowed between coats. A new roof should receive three coats. Metal gutters and spouts are to be treated the same way. Do not forget that new tin or galvanized iron is difficult to paint; have it very thoroughly scrubbed, even though it looks perfectly clean, and then rub the paint on well with the brush. Metal spouts will usually be painted the same color as the wall of the house.

Sometimes shingle roofs are painted with fireproof paint. This is not really fireproof, but considerably retards the spread of fire, after it has become thoroughly dry; when fresh, it does not even do that; nor does it have much effect after it has been on a year or so. It may be made by adding to a gallon of any good paint about a pound of powdered boracic acid. When strongly heated, this material fuses and forms a sort of glass, which keeps the air from the wood. It is after a time washed out by the rain.

Canvas roofs are prepared in the following manner: The canvas

(10-ounce duck is often used) is first nailed down, care being taken to draw it tight; it will show some wrinkles, but these are not to be allowed to accumulate to form a large wrinkle or fold. Then the canvas is thoroughly wet; it shrinks, and all the little wrinkles disappear. It is a common practice to paint it while it is still wet, this being an exception to all other practice; but some wait until it is dry. The writer has been accustomed to the latter method, and has not found that the canvas shows wrinkles on drying, while the results are all that can be desired. A well-painted canvas roof is very durable and satisfactory.

PAINTING STRUCTURAL METAL

Steel is a more perishable material than wood, and more difficult to paint. Without regular expenditure for maintenance, wooden bridges last longer than steel ones; there are wooden roof beams a thousand years old; and iron roofs are so short-lived that they are used only over furnaces and the like, where wooden ones would take fire. The painting of structural steel is therefore important; and it is also difficult, if we are to judge by results.

In the first place comes the preparation of the surface. When we paint wood, we have the surface clean and dry; and then we soak it with oil, so as to have the paint bound to it in the most intimate manner. Iron and steel, on the other hand, always come to us dirty, and covered with oxide; and as the surface is not porous, the paint does not penetrate it, but has to stick on the outside the best way it can. If we paint over the dirt and scale, and that ever comes off, the paint comes off with it; if the metal is actively rusting, and we paint over the rust, the corrosion is perhaps made slower, but it does not stop.

Air and moisture cause rust; if we can keep them away, the metal will last; but, unfortunately, all paint is very slightly porous, and if exposed to the weather it in time deteriorates. The most essential thing in painting metal is to *get the paint on the metal,* not on an intermediate coating.

There are only two ways to clean steel perfectly. One is by pickling it in dilute acid (usually 10 to 20 per cent sulphuric acid), followed by washing to remove the acid; and the other is by the use of the sand-blast. Neither of these processes is available to the ordinary painter, who must do the next best thing. This is to remove absolutely all dirt and all loose scale and oxide. First clean off the dirt, if any,

with brushes, as it would be cleaned off any other surface. Then, with scrapers and steel-wire brushes, clean off all the scale which will come off. If there is any new rust (not mill scale), it must be well scraped out and cleaned off. This is indispensable. When this is done, immediately paint it, before it begins rusting again.

One of the most popular materials for a first coat is red lead in oil. This must be mixed on the spot, shortly before it is used, because it will harden into a cake in the pail or can if allowed to stand very long. From 30 to 33 pounds of dry red lead is to be mixed with each gallon of oil—not less than 28 in any case. This is immediately painted on the metal; if it is put on in too thick a coat, it will run and be uneven. Some use raw oil, others boiled oil; it does not make much difference which is used. The paint dries rapidly; and as soon as it seems hard, a second coat of the paint can be applied. Red lead is different from all other paints in this, that it will finish hardening just as well away from the air. This is because it does not dry by oxidation, as other paints do, but by the lead combining chemically with the oil, just as water combines with Portland cement. In the opinion of the writer, red lead should have one or two coats of some good paint, other than red lead, over it. But red lead is not the only first coating which may be used. Any good paint may be used—a good graphite paint, or other carbon paint, or some of the varnish-like coatings containing linseed oil and asphaltum which are made for the purpose. It is important, in using any of these, to let plenty of time for drying elapse between coats. Not less than two coats is permissible, and three are desirable.

Projecting angles, edges, and bolt and rivet heads are the places which first show rust through the paint. This is partly because the brush draws the paint thin at such places. To overcome this, it is now becoming common practice to go over the work after the first coat, and paint all edges for about an inch from the edge or angle, and all bolt and rivet heads, with an extra or striping coat; then, when the second coat goes on over the whole, there is the equivalent of two full coats everywhere.

Painting on iron, as on wood, should be done in dry weather, when it is not very cold—at any rate not below 50° F. Full, heavy coats should be used, and well brushed on. Care must be taken to get the paint into all cracks and corners.

VARNISH

A varnish is a liquid made to be applied to a surface in a thin film, which, on exposure to the air, hardens into a protective coating that is usually glossy and almost transparent. There are two principal classes—*spirit* and *oleo-resinous varnishes.*

Spirit varnishes, of which *shellac** is the most important, are made by dissolving a resin (or sometimes some other substance) in a volatile solvent, such as alcohol. They dry by evaporation, the solvent going off and leaving the resin spread out in a thin film, the liquid or vehicle having really served as a mechanical means of spreading the resin over the surface. Shellac is a resin which comes on the market in large, thin flakes. It may be dissolved in denatured (or any other) alcohol in the following manner:

Put the alcohol in an earthenware jar, and weigh out five pounds of gum shellac for each gallon of alcohol. Just before leaving at night, carefully and gently drop the shellac, little by little, into the jar of alcohol, then put on the cover and leave it until morning. Do not on any account stir it. In the morning the flakes of shellac will be soaked and swollen; but if you had stirred them in, the night before, they would have stuck together in lumps. Now, during the day, stir the mass with a wooden stick once every hour or so; do not put any metal in it, especially iron; one iron nail will spoil the color of a whole barrel of shellac. By the next morning—perhaps before—the shellac will be ready for use. It does not make a clear solution, because the gum shellac contains some wax, which does not dissolve, and so the varnish is milky or cloudy; it is, however, ready for use. As the alcohol is volatile, the jar should be kept covered; and after it is made, the varnish should be put in glass bottles or clean tin cans.

There are many grades of shellac gum, the best being known by the letters D C; but there are others nearly as good. The common shellac is brownish yellow, and is called *orange shellac;* this is the natural shellac color. White shellac is made from this by bleaching with chlorine; but it is not of so good quality as the unbleached; it has, of course, the advantage of being much paler in color. White shellac gum will, on long standing, sometimes become insoluble. Shellac

* NOTE.—By some painters, the term "varnish" is never used to include shellac. There is, however, no valid, objective reason for thus limiting the use of the term.

varnish may be thinned with alcohol, and often this is necessary. Shellac is too often adulterated with common rosin, which greatly lessens its value. This is easily detected by a chemical test.

Damar is a white resin which is soluble in spirits of turpentine—five or six pounds of resin to a gallon of turpentine. It is the most nearly colorless varnish we have, but never becomes very hard. It is used to a considerable extent as a vehicle for white lead and zinc, to make a very white enamel paint. It is not durable if exposed to the weather.

More important than spirit varnishes are the oleo-resinous varnishes, which consist of certain resins dissolved in linseed oil, the mixture being thinned with turpentine or benzine. In making these, the resin is put in a copper kettle and heated until it is thoroughly melted; then some hot oil is added to it, and the mixture cooked until the whole is thoroughly combined. The kettle is then taken from the fire, and when partly cool, the turpentine is stirred in. The resin makes the film hard and lustrous, and the oil makes it tough. Thus the larger the proportion of resin, the harder and more brilliant will be the film; the larger the proportion of oil, the tougher, more elastic, and more durable it will be, and the slower it will dry. Most of the color of varnish comes from the resin; the paler this is, the paler will be the varnish. The pale gums are higher in price than the dark ones, but are no better in any respect except color. Dark varnishes may be just as good (except in color) as pale ones—in fact may be better, for the dark resins are often harder and better than the pale ones of the same sort. The hard and quick-drying varnishes are suitable for furniture; the medium, for interior house-varnishes; the slow and elastic, for exposure to the weather.

Varnishing. The wood should be dry. For this reason it is better, if necessary to clean it, to avoid washing as much as possible, using sandpaper instead, which will also make it smooth. Of course the carpenter is supposed to do this, but the painter must not neglect it on that account. When in proper condition, it first receives, if it is an *open-grain* wood, a coat of paste filler. The open-grained woods in most common use are oak, chestnut, and ash. The woods classed as *close-grain* woods are white pine, maple, birch, yellow pine, white-wood, cherry, and sycamore. These latter do not need filling. If filler is used, it should be well rubbed in with a short, stiff brush; and

when it has set, say in fifteen to thirty minutes, it is rubbed off with a handful of excelsior, rubbing across the grain, and rubbing hard, so as to force the filler well into the pores of the wood. Then it should stand 24 to 48 hours.

When purchased, a paste filler is too thick to be used with a brush, and must be thinned with turpentine or benzine; at the same time it may be stained to any desired color with an oil or varnish stain. These stains can be purchased of any desired color. If a close-grained wood is under treatment, the first thing is to apply a stain if it is desired to stain the wood; but it is common practice to finish in the natural color. Stains usually require a good deal of thinning before using; the amount of thinning will determine the depth of color. Water stains are seldom used, as they tend to raise the grain of the wood.

In cleaning off the filler, be careful to clean out corners and mouldings, using for this purpose, properly shaped hardwood sticks; do not use any steel tool.

Where rooms are to be finished in the natural color of the wood, it is nevertheless a common practice to stain the window-sashes; a cherry or light mahogany stain is often used. Fillers are sometimes used on close-grain woods; but this is not advisable, as they tend to prevent the varnish from getting a good hold on the wood.

Next comes the varnishing. Window-sills, jambs, inside blinds, and other surfaces exposed to the direct rays of the sun, are to be treated as exterior woodwork, and are not varnished with the ordinary interior varnish used on the rest of the work. The floors also are left out of account for the present. The rest of the woodwork receives its first coat of varnish; apply it, as much as possible, with the grain of the wood, brushing it out well in a thin coat. The varnish ought to dry dust free (*i.e.*, so that dust will not stick to it) over night; but at least five days should elapse between coats. When dry, it should be rubbed with curled hair or excelsior enough to remove the gloss, so that the next coat of varnish will adhere properly; a better result will be had if it is lightly sandpapered with 00 paper. The second coat is treated like the first. The third is not sandpapered, but rubbed with curled hair; the fourth or finishing coat may be left with the natural gloss, or, if preferred, it may be rubbed with fine pumice and water to a smooth, dull surface. For this purpose the varnish dealers sell felt, about an inch thick, which is well wet in clean water; a little dry pumice powder is

put on it; and the rubbing is done with this. The varnish must be quite hard and dry before this is attempted. Varnishing, if properly done, is slow work; that is, much time must be allowed for each coat to dry thoroughly.

The varnish which is used on interior woodwork should not dry too quickly; it should dry enough over night so that dust will not stick to it, and in twenty-four hours should be hard enough to handle freely; but if a chair, for example, were varnished with it, it would not be entirely safe to sit on it for a week. It should, however, finally become perfectly free from tack, which it will not do if it is a rosin varnish. At present prices (and it is not probable that they will ever be lower) varnishes for interior woodwork are sold, according to color and quality, at prices ranging from $2.50 to $4.00 a gallon. It is in the highest degree inadmissible to use a cheap varnish for undercoats; the outer coats will crack if this is done. A good varnish that dries too quickly, such as what is called a *rubbing varnish*, or one intended for furniture, has not the durability needed for this work. It is economy to use a good varnish. The writer has in mind a house which was properly varnished eighteen years ago and has been constantly occupied by a large family, yet the varnish is still in fair condition; if it were lightly sand-papered and one new coat applied, it would be like new—as good as it is possible for a surface to be. Cheap rosin varnishes never look well, even when new, never keep clean, and deteriorate rapidly.

Shellac. Interiors are sometimes finished with shellac. This varnish is not used on exterior work, but it is a good varnish for interiors. All varnishes containing oil darken the color of wood; but white shellac is comparatively free from this objection; at any rate it does it less than anything else. Orange shellac is a dark varnish, and even white shellac darkens with age to an appreciable degree. Orange shellac is more durable than white, and should be used wherever admissible, rather than white; but it is usually necessary to use white shellac for this service. If shellac is made up as heavy as has been described—five pounds to a gallon of alcohol, and this is the standard—it should be thinned considerably with alcohol before using on interior woodwork. It must be applied in thin coats, and given plenty of time to dry. It is very deceptive about this; it appears to be dry and hard in an hour, and it is hard enough to handle freely; but if we apply coat after coat, even six hours apart, we shall find that the wood is

finally covered with a waxy mess which will be the source of nothing but trouble. The first coat sinks rapidly into the wood; a second coat may be applied six hours later; but after that, allow two days at least between coats. Shellac makes a very thin coat; so it is necessary to apply a large number of coats, at least twice as many as of oleo-resinous varnishes, to get a sufficient thickness of coating. Because of this labor, shellac is an expensive finish; but it is handsome and durable. The treatment of it, as regards rubbing, etc., is the same as has been described for other varnish.

Varnish makers usually advise that shellac should never be used as a priming coat for other varnish; this is probably because they wish to sell more of their own goods, for shellac is really an excellent first coat, except for exterior work, where it should not be used. Of course, wood should be filled before shellacking, the same as for other varnish. Varnish does not, however, wear well over a heavily shellacked surface. Shellac makes a good floor varnish, discoloring the wood very little, and wearing fairly well. After the floor has been well varnished with it, very thin coats, applied rather frequently—say every one to four months, according to use—will keep the floor in fine condition; and after applying one of these thin coats (of thinned shellac), it will be dry enough to use in an hour. This can be applied with a very wide, flat brush, and a man can go over the floor of an ordinary room in a few minutes. Shellac brushes should be washed out with alcohol immediately after using.

Exterior Varnishing. Varnishes dry much more rapidly out of doors than within, so that it is practicable to use more elastic and durable materials. The conditions, in fact, are so severe that the best are not good enough. In the first place, do not use any filler on exterior work; it will probably crumble and come out. Do not use shellac; as an undercoat exposed to the hot sun, it will soften and blister. Use only the best *spar varnish*, such as is made for varnishing the spars of yachts; fill the wood with it; sandpaper lightly between coats, just enough so that each succeeding coat will take hold well; finish with a coat well flowed on; and leave it with its natural gloss, which is more lasting than a rubbed surface. This is the treatment for hand-rails, outside doors, inside blinds, window-sills and jambs, and everything exposed to the direct sun. Hand-rails and outside doors should be refinished every year; varnish will

not last on an outside door more than one-twentieth as long as it will on an inside door. Never use interior varnish for outside work.

ENAMEL PAINTS

Varnishes are all more or less brownish yellow or yellowish brown. Therefore a coat of varnish applied over a paint obscures and changes its color to some extent. To overcome this as much as possible, the varnish, instead of oil, is mixed with the pigment, as a vehicle. In this way the pigment comes to the surface and displays its color. These paints, if made with good varnish, are durable; the method of application has already been described. If necessary to thin them, do it with spar varnish instead of oil; a good interior varnish may be used, but it injures the flowing quality of the paint somewhat.

White lead and zinc are sometimes mixed with damar varnish. This makes the whitest enamel paint, but it never gets very hard, never has much luster, and is not very durable. It is very white, is easily applied, and dries quickly.

A NEW VARNISH FINISH

A method of finishing open-grained interior woodwork, which has been practiced for a few years, consists in first staining the wood with a water-stain—dyeing it, usually—and then, when it is dry, filling the pores of the wood with a paste filler which has been colored by the addition of a pigment. For example, the wood may receive a stain of any dark color, and the wood-filler be mixed with white lead. This shows the open or porous part of the grain in white on a dark background. By using artistic combinations of color in the stain and filler, very beautiful effects can be produced, and this finish has been used in some of the most handsome and costly public and private buildings. Thus, if a room is to be decorated in green, the woodwork can be made to harmonize with the prevailing color. An oil stain must not be used on the wood, as it will not work well with the filler. The colored filler is applied and rubbed off in the same way that any paste filler is used, and then the varnish is applied over it in the usual way.

FLOOR FINISHING

The primary trouble with floors is that people walk on them. If they did not, there would be no trouble at all. Four coats of varnish,

or even paint, having an aggregate thickness of less than one one-hundredth of an inch, will not last indefinitely under the wear of nail-shod heels.

Probably the simplest treatment for floors is painting them. The paint should contain a large proportion of a hard oleo-resinous varnish; an ordinary oil paint is not hard enough. If an oil paint is used, it must be heavily charged with dryer, for a floor paint should dry in twelve hours. Good quick-drying floor paints are in the market.

Floors of choice wood, however, are not usually painted; they may be either varnished or waxed. If they are of oak or other open-grained wood, they must be filled with a paste filler; otherwise the varnish is applied directly to the wood. Floor varnish is quicker in drying, and harder than interior finishing varnish, but should not be so hard as to be brittle; rubbing varnish is too hard. If the floor is to be stained, this is done with an oil stain before varnishing; if it is a floor which has previously been varnished, so that the stain will not penetrate the wood, the stain may be mixed with the varnish, although the effect is not then so good.

Floor wax is not made of beeswax, but of a harder vegetable wax, and is sold by all paint dealers. The floor should receive one coat of shellac; then the floor wax may be rubbed on with a stiff brush, and when it is dry, which will be in a few hours, it may be polished by rubbing with a clean cloth or with a heavy, weighted floor brush made for the purpose. It should receive another coat every week until four or six coats have been applied; after this a little of the floor wax, thinned if necessary with turpentine, should be applied often enough to keep the floor looking well. Alkalies dissolve the wax, and in cleaning the floor only a little soap should be used in the water with which the floor is washed. A wax finish kept polished with a polishing brush, is the handsomest surface than can be obtained for a floor; but it is so slippery that it is somewhat dangerous. It does not discolor the wood. Interior trim (but not hand-rails) is sometimes wax-finished. This finish requires a good deal of care, as it is likely to catch dust; otherwise it is handsome and durable.

Old floors which require cleaning and revarnishing should have the old varnish or paint removed by a good *varnish-remover*, one of the modern sort, free from alkali. This is painted over the surface, and,

after a short time, removed with a scraper. The last of the varnish-remover is taken out with a rag wet with turpentine or benzine, care being taken that there is no fire of any sort in the room or any neighboring room. This will not only take off the old varnish, but the old filler also; and the floor must be treated like a new floor. Any stains on the floor may be treated with a hot solution of oxalic acid, one part to ten of water; when the stains disappear, wash well with clear water; let the floor dry a day; sandpaper; and it is ready for varnishing again. This treatment—removal of old paint or varnish by a liquid varnish-remover—is applicable to all varnished or painted work. The outside of a house could have the old paint taken off in this way, but *burning off* is cheaper and quicker. These varnish-removers are mixtures of benzole, acetone, alcohol, and other liquids, and the best of them are patented.

ALUMINUM AND BRONZE PAINTS

Radiators and pipes are often painted with aluminum or bronze paints. These consist of metallic powders, in fine flakes, mixed with some varnish—usually with a pyroxylin varnish, which is a thin solution of a variety of gun-cotton in a suitable solvent, generally acetate of amyl. If one of these paints—which smell somewhat like bananas—becomes thickened in the can by evaporation, it can usually be thinned with acetate of amyl, if some of the special thinner cannot be had; brushes can be washed out in the same. A good aluminum paint is durable, even exposed to the weather. One coat is usually enough, two certainly so.

GLAZING

House painters are usually expected to understand the art of setting window-glass; it is not difficult to learn. Glass is classified as *sheet* or *cylinder glass* and *plate glass.* Sheet glass is made, at the glass works, by blowing a quantity of glass, first, into a hollow globe; then, by more blowing and manipulation, this is stretched out into a hollow cylinder perhaps a foot in diameter and five feet long; this cylinder (whence the name "cylinder glass") is cut open, and, after reheating, is flattened out into a sheet, whence the name "sheet glass;" after annealing, it is cut up into convenient sizes. It is made of two

thicknesses—*single thick*, which is about one-sixteenth of an inch; and *double thick*, one-eighth of an inch; but it does not run perfectly uniform. All sheet glass contains streaks, bubbles, and specks of dirt, and is more or less irregular or wavy in its surface; and in respect to this it is graded as first, second, and third quality; in American glass these grades are usually marked "AA," "A," and "B;" and anything poorer than "B" is called *stock sheets*. Foreign glass is not thus marked, each maker having his own arbitrary marks. Single-thick glass is used for sizes not greater than about 28 by 34 inches; double-thick, up to 40 by 60. For larger sizes, plate glass only is used; but of course either plate or double-thick can be used for small sizes, if desired.

Plate glass is cast in plates; the liquid glass is poured out on an iron table, about 15 feet wide and 25 feet long, and smoothed down to a uniform thickness of half or five-eighths of an inch by passing a roller over it, like rolling pie-crust; after this it is ground down with sand, emery, and polishing powder to a quarter or five-sixteenths of an inch in thickness. It is therefore much more costly than sheet glass, but is also more perfect.

Crystal is a very thin plate glass, about one-eighth of an inch thick, and is used where ordinary plate is too heavy, as in movable sash. It is the finest of all window glass. There are two grades of plate glass, known as *glazing* (for windows) and *silvering* (for mirrors), the latter being the best. In the first place, the sash is prepared for the glass. It must receive a priming coat; if it is to be painted, it is primed with white lead and boiled linseed oil, the mixture having very little or no turpentine added; if it is to be varnished, it is primed with boiled oil alone. If it is not primed, the putty will not stick; the wood will draw the oil out of the putty and leave it crumbly. Next, the glass is fitted to the sash. It is cut either with a glass-cutter's diamond or with a wheel cutter, the latter being a little sharp-edged steel wheel set in a handle. If well made, the wheels may be bought separate and are replaceable. The wheel cutters are generally used on sheet glass; but plate glass is cut only with a diamond, which makes a deeper cut. The wheels are kept wet with kerosene; the workman has a little bottle or cup of kerosene on the bench, and dips the wheel in it.

The glass being cut to the right size, a layer of putty is spread, with the putty-knife, along the recess in the sash where the glass is to

rest. This is called *bedding* the glass, and should always be done. It is not uncommonly omitted with pine sash; but it absolutely must be done with all hardwood sash, metal or metal-lined sash, and for all plate and crystal glass; and it ought to be done in all cases. Then the glass is gently pressed into place, after which it is fastened with *glaziers' points,* which are triangular bits of metal. No. 2 points are used on single-thick, and No. 1, which are larger, are used on double-thick glass; they are put in 9 to 12 inches apart. They are driven, not with a hammer, but with the thin side of a two-inch chisel, the flat side of which lies on the glass, the edge of the chisel away from the surface so as to avoid scratching it. The chisel is also useful for adjusting the position of the pane; if it is smaller than the sash, it is so placed that when the sash is in its natural upright position the pane of glass will rest with its lower edge bearing on the wood. The points are commonly of zinc, which bends easily; and when the pane is properly placed, if there is on one side a space between it and the wood, the chisel is held over this crack, and with its edge an indentation or crimp is made in the little triangular zinc point which has already been driven; this crimp prevents the glass from sliding back against the wood. This is the reason zinc is used for the points; it will bend. Steel points are sometimes used for plate glass, because of their greater strength, the glass being heavy. To drive through the sheet metal of metal-covered sash, steel slugs are used; these are about $\frac{1}{20}$ inch thick, about $\frac{7}{8}$ inch long, and $\frac{7}{16}$ inch wide at the wide end, triangular, and sharp-pointed.

There is a machine for driving points, but it is not much used except on small glass set in soft-wood sash.

The glass being properly secured by points, it is ready for puttying. To do this, the professionals set the sash up in a nearly vertical position on an easel; the glass is puttied on the right-hand side and across the bottom; then the sash is turned the other edge up, and the operation is repeated. This finishes the work.

The most important things about glazing are to use a sufficient number of points and to use good putty. Ordinary (pure) putty is made of whiting, which is pulverized chalk, mixed with enough linseed oil to give it the consistence of stiff dough. The workman can make it from these materials with his hands; everyone can make his own putty. As a matter of fact, however, the putty of commerce is made by ma-

chinery; and also, as a matter of fact, it is in general abominably adulterated. It would seem as though whiting and linseed oil were materials cheap enough; and in reality putty can be sold for about three cents a pound, or sixty dollars a ton; and a dollar's worth will putty all the glass in an ordinary house. Pure putty, however, is almost impossible to get. Marble dust is substituted for whiting, and a mixture of rosin and mineral oils for the oil, and the cost reduced about half. It is the use of this miserable stuff which causes nine-tenths of the troubles with windows. If the glazier cannot be sure of his putty otherwise, he should make it himself.

The best putty for glazing is a mixture of pure whiting putty with one-tenth white lead putty. This makes it set a little more quickly, and it becomes harder. Pure white lead putty gets too hard; it is too difficult to remove it in case of breakage of glass.

If the glass has not been bedded in putty, it is customary to go around the indoors side of the glass, and crowd some putty into the crack between it and the sash. This is called *backing* the glass. Large plates of plate glass are not puttied, but are held in place with strips of moulding nailed on the sash, in which case the crack between the glass and the moulding is backed with putty.